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Enterprise
Chemical Coatings Company

Final Report On Polymeric Beads
for Organic Coatings

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POLYMERIC BEADS FOR ORGANIC COATINGS

FINAL REPORT

FOR

CONTRACT DAAK 70-81-C-0125

SUBMITTED BY THE ENTERPRISE CHEMICAL COATINGS COMPANY

OCTOBER 31, 1982

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SECTION 1

SUMMARY

This report describes the research performed under contract DAAK 70-81-C-0126 on the utilization of polymeric bead technology in camouflage coatings. The primary objective of this program was to determine the feasibility of adapting polymeric bead technology to the Army's needs in camouflage coatings.

Clear polymeric beads were used in place of all inerts in the following camouflage specifications:

- Mil-E-52798A, Air Dry Alkyd Enamel
- Mil-E-52929, Flash Dry Alkyd Enamel
- Mil-C-46168A, Chemical Agent Resistant Urethane.

When the polymeric beads were incorporated into each of these specifications, it was observed that the beads effectively lowered gloss and improved mar-resistance, cleanability and weather-resistance of the coating.

The concept of a transparent chemical-agent-resistant urethane over coat, containing clear vesiculated beads, was also investigated. The intent was to be able to apply this clear urethane over tactical vehicles already painted with conventional alkyd camouflage coatings thus imparting chemical-agent-resistance. Ten micron clear vesiculated beads were found to be a necessary part of this formulation in order to achieve the low gloss required by the specification without harming the transparency of the film.

A variety of pigments common to camouflage paint formulation were encapsulated. It was found to be possible to produce a Forest Green camouflage coating in which all prime pigments and inerts were replaced with pigmented beads.

The research summarized in this report indicates that polymeric bead technology can be beneficial for camouflage coatings. The data supports the conclusions that polymeric beads effectively lower gloss while improving the mar-resistance, cleanability and weather-resistance of a camouflage coating.

SECTION II

PREFACE

This report was prepared by J. W. Uphoff, V. R. Ecker, E. Oberg and J. M. Stone of the Enterprise Chemical Coatings Company, Wheeling, Illinois, under Contract DAAK 70-81-C-0126. The title of this research project was "Polymeric Beads for Organic Coatings."

This project was issued by the U. S. Army Mobility Equipment Research and Development Command, Procurement and Production Directorate, Fort Belvoir, Virginia, in coordination with Fred Lafferman, Chief - Organics/Chemical Coatings Research Group. The contract was administered by DCASMA, Chicago, O'Hare International Airport, Chicago, Illinois.

The research performed under this contract was conducted from July, 1981 through June, 1982.

SECTION III

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SECTION IV

INTRODUCTION

In July, 1981, the U. S. Army Mobility Equipment Research and Development Command (MERADCOM) awarded contract DAAK 70-81-C-0126 to the Enterprise Chemical Coatings Company to investigate the utilization of polymeric bead technology in camouflage coatings. The primary objective of this program was to develop a beaded camouflage coating that has the following benefits while still conforming to the spectral and performance characteristics of the Army camouflage specifications:

- Improved mar resistance;
- Improved weather resistance; and
- Improved cost effectiveness.

These improvements in camouflage coatings are important to the Army for several reasons. Conventional coatings mar very easily due to the high loading of inerts required to achieve the very low gloss specified. The marring is detrimental to both the visual appearance of the coating as well as harming the film's infrared color properties.

Conventional camouflage enamels tend to generate a white chalk-face upon weathering due to the large quantities of inerts that are typically in these formulas. The white chalk-face will also destroy the camouflage spectral color characteristics of the coating.

With the advent of the Army moving toward utilization of a more expensive urethane coating, the need for cost effective formulations becomes increasingly important. Pigmented beads offered a potential formulation tool for reducing total pigment costs in camouflage systems.

With these goals in mind, contract DAAK 70-81-C-0126 was started to determine whether the use of polymeric beads would offer a feasible solution to the Army's future camouflage coatings requirements.

SECTION V

BACKGROUND

This report describes the steps that were taken to determine the feasibility of using beads in camouflage coatings systems. In order to understand the terminology associated with polymeric bead technology a few of the terms that are commonly used are defined below:

A. POLYMERIC BEADS

A Polymeric bead is a microscopic sphere that is produced by a patented suspension polymerization process. The polymerization of an unsaturated polyester/styrene mixture forms the polymeric structure of the bead. The research performed under this contract was done with beads that were either 25 microns or 10 microns in top size.

B. POLYMERIC BEAD CLASSIFICATIONS

Polymeric beads can be classified into four main categories:

- Clear Solid Polymeric Beads
- Clear Vesiculated Polymeric Beads
- Pigmented Solid Polymeric Beads
- Pigmented Vesiculated Polymeric Beads.

1. Clear Solid Polymeric Beads

A solid polymeric bead is comprised of a solid mass of polymerized unsaturated polyester/styrene resin mixture.

2. Clear Vesiculated Polymeric Beads

A vesiculated bead contains entrapped air vessicles. The outer shell of the beads and the walls of each vessicle are composed of the polyester/styrene polymer. As light is refracted by the interfaces of the vessicles of the bead, a whitening or opacifying optical effect occurs.

3. Pigmented Solid Polymeric Beads

Pigment can be added to polyester/styrene mixtures to form a solid, pigmented polymeric mass.

4. Pigmented Vesiculated Polymeric Beads

Encapsulation of pigment in a vesiculated bead results in a random distribution of pigment particles within the polymeric walls that surround each air vessicle. Figure 1 is a photograph taken by a scanning electron microscope of a field of titanium vesiculated beads. Figure 2 is a photograph of one eleven micron bead. The shadowy dimpled areas are the vessicles as seen from an outside view of the bead. A cross-section of a vesiculated bead is shown in Figure 3. The inside of a vesiculated bead has a honeycomb structure. The dark, shadowy areas are the air vessicles while the very white areas are the titanium pigment that has been encapsulated in the walls of the bead.

The majority of the research work performed under this contract was done with clear vesiculated polymeric beads as a replacement for the conventional talcs and inerts that are typically used to lower the gloss and sheen of camouflage systems. Vesiculated beads were chosen because a comparison of clear, solid and clear vesiculated beads showed that the vesiculated beads lower gloss more efficiently, with a minimal effect on cost and color properties. Clear beads were also selected for our initial work so that the effect of the bead alone could be examined in a camouflage coating (see Table 1).

In order to determine the feasibility of utilizing polymeric beads in camouflage coatings, it was necessary to evaluate the beads in all three of the primary camouflage specifications:

- Mil-E-52798A, Air Dry Alkyd Enamel, Type I and II
- Mil-E52929, Flash Dry Alkyd Enamel, Type I and II
- Mil-E-46168A, Chemical Agent Resistant Urethane, Type I and II.

Most of the preliminary work performed in each specification was done in the Forest Green color, since this color historically is the most commonly used camouflage color and is also the most difficult green to match for color.

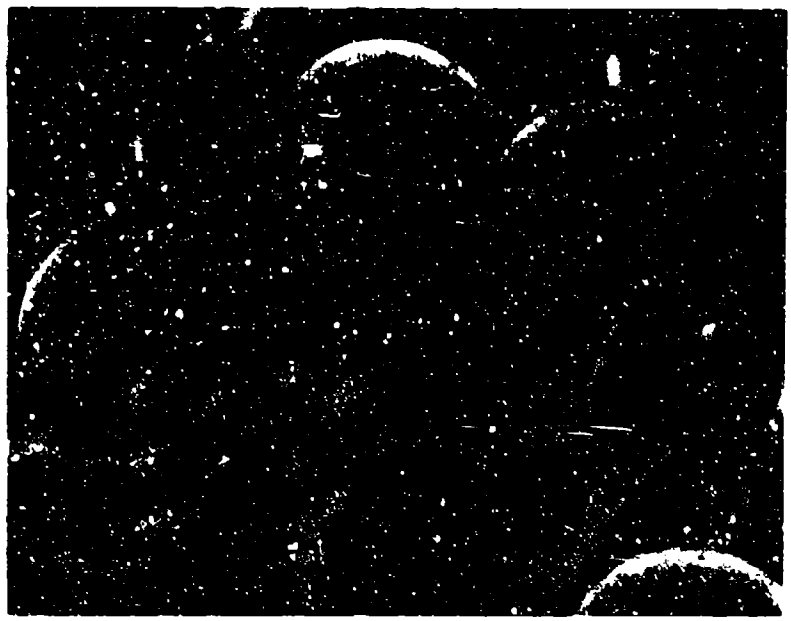


FIGURE 1

25 MICRON (TOP SIZE) TITANIUM VESICULATED BEADS

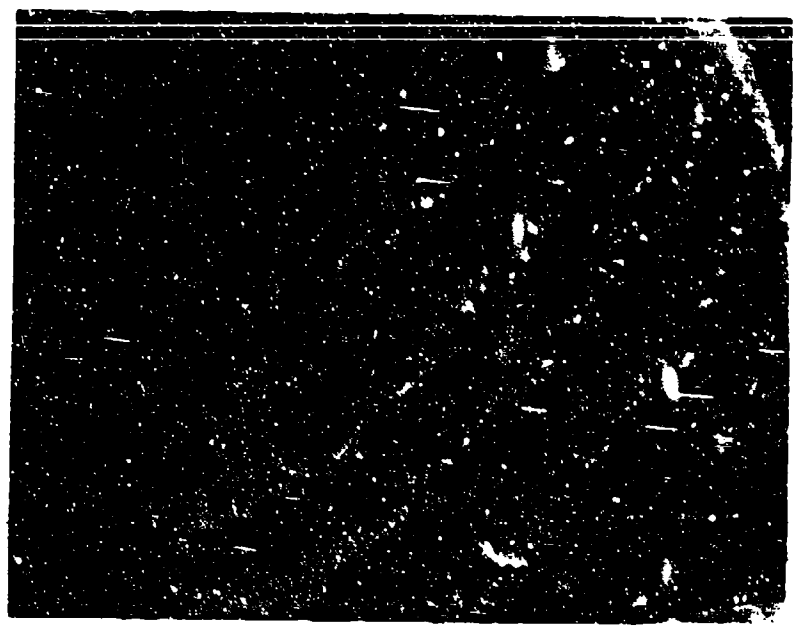


FIGURE 2

AN 11 MICRON TITANIUM VESICULATED BEAD

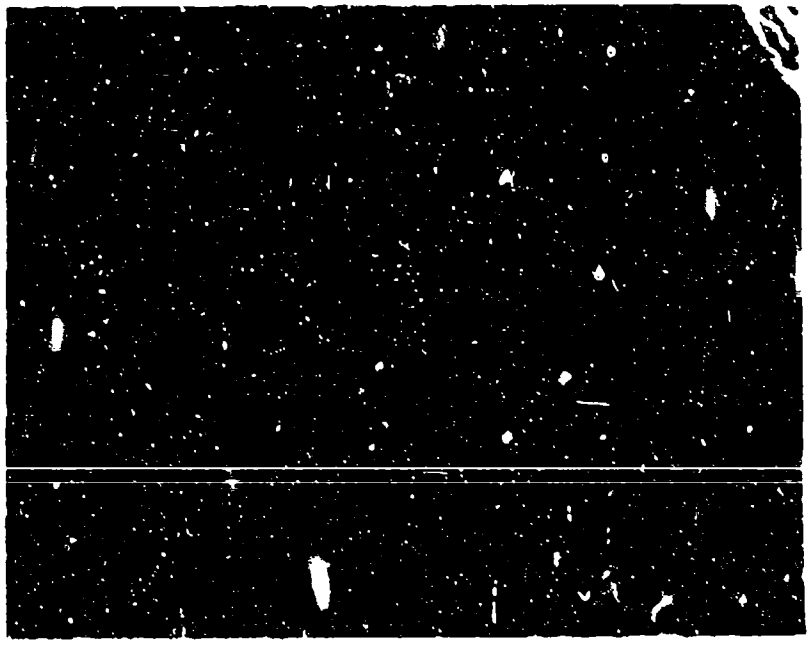


FIGURE 3

CROSS-SECTION OF AN 11 MICRON TITANIUM VESICULATED BEAD

Additional information is presented that describes our efforts to make a transparent, low gloss, chemical-agent-resistant urethane coating with clear polymeric beads. This concept would allow the Army to repaint tactical vehicles that had been previously coated with conventional alkyd camouflage systems with a clear coating that would give the vehicle chemical-agent-resistance while maintaining the original camouflage spectral properties. The beads are necessary to provide the required low gloss. Use of conventional inerts to lower gloss in the clear urethane would cause the film to become opaque and distort the original camouflage color.

The remainder of our research work centered around replacement of all conventional camouflage pigments and inerts with pigmented vesiculated beads. Results of that work are also presented in this report.

SECTION VI

INVESTIGATION

During the course of this contract, our research determined that polymeric beads can be used successfully in camouflage coatings to provide a low gloss finish that has improved mar-resistance, and improved weather-resistance over current camouflage coating systems. It was also determined that the clear polymeric bead structure is resistant to the harsh decontaminant, DS_2 as well as other chemical agents. An evaluation of clear polymeric beads in MIL-C-46168A, Aliphatic Polyurethane, showed that these beads are chemical-agent-resistant.

Formulas for the following camouflage specifications and the respective colors in those specifications have been developed utilizing polymeric bead technology:

- MIL-E-52798A, Air Dry Alkyd Enamel, Forest Green, Type I and Type II
- MIL-E-52929, Flash Dry Alkyd Enamel, Forest Green, Type I and Type II
- MIL-C-46168A, Chemical Agent Resistant Coating
  - Colors:
    - -- Forest Green, Lead-Containing
    - -- Forest Green, Lead-Free
    - -- Black
    - -- Aircraft Insignia Blue
    - -- Field Drab
    - -- Olive Drab (Federal Color Standard 595-34087)
    - -- Sand
    - -- Aircraft White
    - -- Aircraft Black
    - -- Aircraft Green
    - -- Clear.

A clear chemical-agent-resistant urethane top coat formula, containing clear vesiculated beads was developed for the purpose of top coating existing camouflage coatings that are not chemical-agent-resistant. The clear coating has the low gloss required of a camouflage coating and does not distort the spectral properties of the original coating.

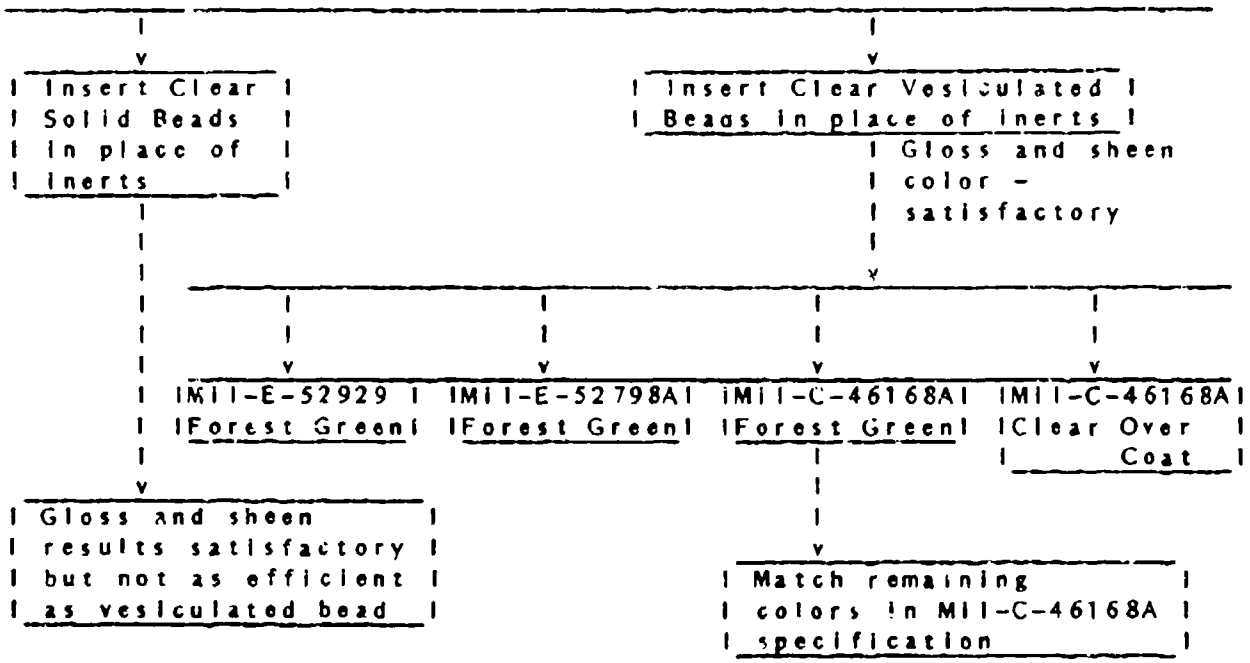
A Forest Green, conforming to MIL-C-46168A, urethane, was also developed, utilizing pigmented vesiculated beads in the place of all prime pigments and inerts in the formulation. Optimization of this formula is not complete but our research indicates that this is a feasible approach.

Actual test results are included in Section VII of this report. The most significant test methods and equipment actually used for test purposes are described in Table 2. While the other physical properties required by each specification were also evaluated on final beaded formulations, those tests listed in Table 2 were run routinely on samples in order to determine the direction our research should follow.

Since there was no previously published research literature on the use of polymeric beads in camouflage coatings, it was necessary to first determine which clear bead, solid or vesiculated gave the most desirable properties. The flow-chart of Table 3 describes, very simply, the path our research on clear beads followed during the course of this contract. The camouflage coatings subsequently developed with clear vesiculated beads met the requirements outlined in each respective specification.

TABLE 3

CONVENTIONAL CAMOUFLAGE COATING



SECTION VII

DISCUSSION

At the beginning of this contract, large standard lots of the raw materials used in conventional camouflage coatings were set aside for the purposes of our work. This was done so that we could assure ourselves that any changes between a conventional camouflage coating and the beaded camouflage coating were attributed to the bead alone.

The objective of the initial series of experiments conducted was to determine if all of the conventional gloss reduction materials used in camouflage coatings, such as talc and diatomaceous silicas, could be replaced with clear beads and still obtain the required gloss and sheen. At this point, we removed all of the inerts in a MIL-C-46168A, Forest Green formula, and inserted 0.4 pounds per gallon of clear solid beads in one sample and 0.4 pounds per gallon of clear vesiculated beads in another sample. The results of this trial are summarized in Table 1. From the data it can be seen that the clear vesiculated bead lowered the gloss and sheen into the specified range while the clear solid bead formula was out-of-specification. The next step was to determine the quantity of solid beads required to achieve the same gloss. Note that five (5) times as many solid beads were required to achieve the same gloss and sheen obtained with clear vesiculated beads.

Based on the results of our initial sets of experiments, we then proceeded to introduce clear vesiculated beads into the three primary camouflage specifications. A summary of the research performed, and data obtained in each specification, is described in the following subsections.

A. CLEAR VESICULATED BEADS

1. MIL-E-52929, Flash Dry Alkyd Enamel

Since the original level of 0.4 pounds per gallon 25 micron clear vesiculated beads initially gave satisfactory color and gloss results, we decided to determine if this was an optimum level of beads to use. An experiment was conducted in which we made samples of MIL-E-52929, Forest Green, Type I, at bead levels of 0.3 pounds, 0.4 pounds and 0.5 pounds per gallon. The color and gloss results of this test are summarized in Table 4.

TABLE 4

MIL-E-52929, FOREST GREEN
COMPARISON OF VARIOUS CLEAR, VESICULATED BEAD LEVELS

Bead Level	60° Gloss	85° Sheen	Cap "Y"	Lx	Ly
0.3 #/Gal.	1.2	1.0	9.87	0.317741	0.37610
0.4 #/Gal.	0.4	0.8	10.32	0.31918	0.38229
0.5 #/Gal.	0.3	0.8	10.79	0.32012	0.38445

As can be seen from these results, the 0.4 pounds per gallon level of clear vesiculated beads offered the most desireable combination of color properties and gloss control. The remainder of our work with this specification was therefore based on the 0.4 pounds per gallon level.

The starting formulation for the conventional MIL-E-52929, Forest Green, Type I camouflage coating is shown in Figure 4. The gloss and color readings, color curve, and position within the ellipse for this system is shown in Figures 5, 6 and 7 respectively.

The initial starting formulation we used to incorporate 25 micron clear vesiculated beads at an 0.4 pound per gallon level is shown in Figure 8. In this formulation, we first dispersed the prime pigment on a sand mill to a 7 N.S. dispersion, then added the beads and sand milled the entire formula to a 4 N.S. grind. The gloss and color readings, color curve and position within the ellipse are shown in Figure 9, 10 and 11. Note that the Cap "Y" and 670 wavelength reading are both high. We were unable to move the color completely into the specification.

A series of wetting agents were evaluated to determine if the color could be moved into the required range. The results of that evaluation are summarized in Table 5. However, while the AMP (2-amino-2-methyl-1-propanol) had the most noticeable effect on the color we still were unable to move the color into position.

An attempt to use a 10 micron clear vesiculated bead in place of a 25 micron bead was then made to see if the smaller bead would give a lower brightness reading. The results of this experiment are shown in Figures 12, 13 and 14. The smaller bead size did not help improve the brightness enough to allow us to shade the color into the required ellipse.

In the next phase of our work, the 25 micron clear vesiculated beads were added to the formula at the same time the prime pigments were added. The entire pigment/bead paste was then sand milled until a 4 N.S. dispersion was obtained. This method of processing was successful in that the color could be readily shaded into the ellipse. The color results are displayed in Figures 15, 16 and 17. After repeating this experiment several times to confirm our results, the formula shown in Figure 18 was established as our final beaded formula for Mil-E-52929, Flash Dry Enamel, Forest Green, Type I. It was with this formulation that we began physical testing of the coating versus the specification.

During the course of our testing, it was observed that the beaded coating displayed two primary benefits over the conventional flash dry system. They are:

- Significantly improved mar-resistance
- Better color retention upon weathering.

The improvement in mar-resistance is best shown in Figure 19. This photograph shows side-by-side panels of a conventional and beaded camouflage flash dry alkyd enamel system. A fingernail was then dragged across the surface of both panels at a constant pressure. From the photograph it is evident that the conventional system marred severly while the beaded system showed little or no marring. A sample of this beaded system was sent to Bendix Communications for evaluation because they were having problems with the conventional Mil-E-52929, Flash Dry Enamel, marring during their equipment assembly. Their testing confirmed that the beaded Mil-E-52929 had superior mar-resistance to the conventional formulation.

The photograph in Figure 20 shows the Q-U-V Weather-Ometer tests that were run on the conventional and beaded systems. These panels were exposed for 300 hours in the Q-U-V. Note that the conventional system has a white chalk-face after 300 hours exposure. The chalking destroys the original camouflage color properties of the coating. However, the beaded panel does not exhibit the same chalking tendency since there are no inerts in this system. This fact is evidenced by the noticeable difference in Cap "Y" reading on the exposed panels. The color and gloss results for the exposed panels are summarized in Figure 21.

FIGURE 19

MIL-E-52929, ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I,
MAR-RESISTANCE COMPARISON OF CONVENTIONAL VS. BEADED SYSTEMS

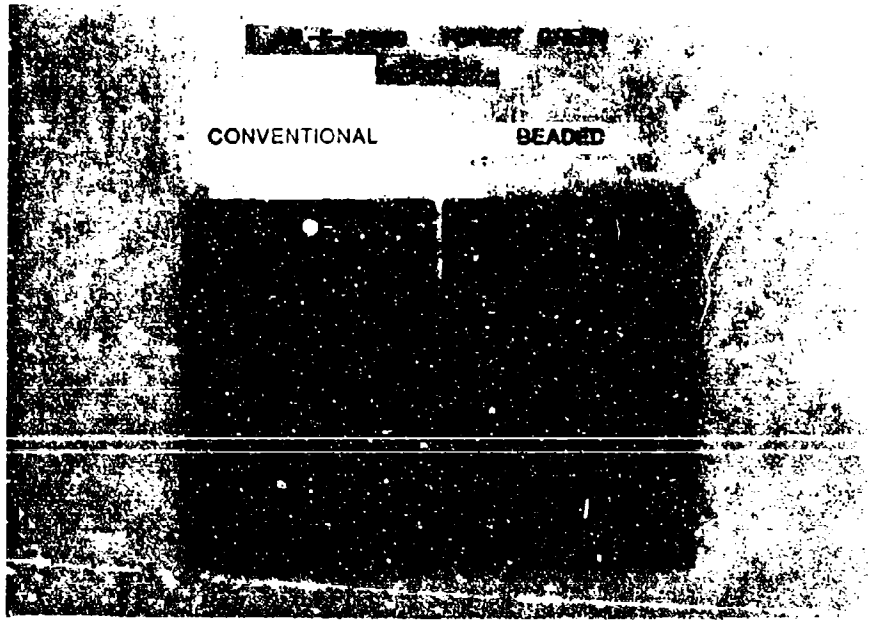
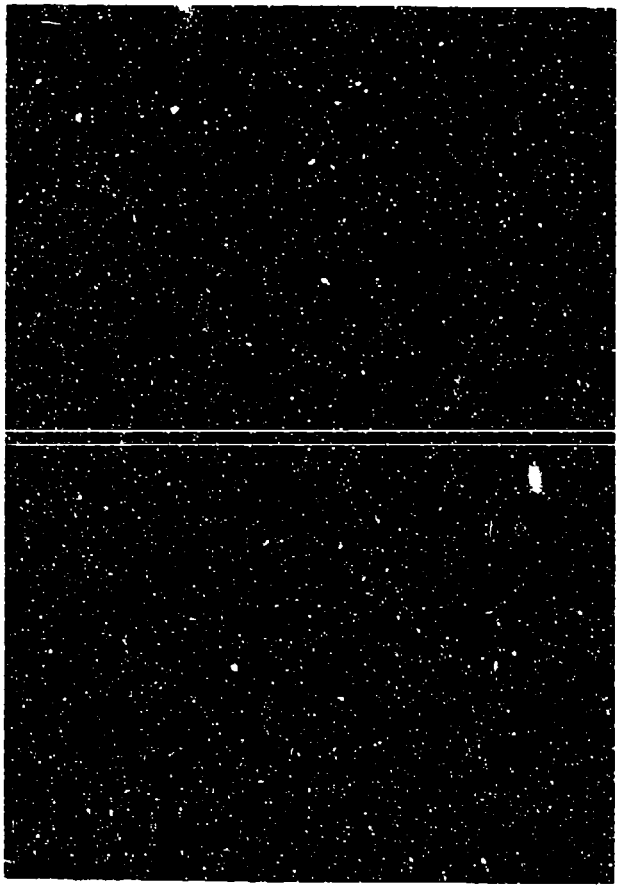


FIGURE 20

MIL-E-52929, ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I,
300 HOUR Q-U-V WEATHER-OMETER EXPOSURE PANELS OF
CONVENTIONAL AND BEADED SYSTEMS



Once the formulation for the beaded Mil-E-52329, Forest Green, Type I was developed, the same technology was utilized to develop a Type II, Lead-Free, Flash Dry Alkyd. The Type II conventional formulation, the final beaded formulation, and the results of the color and gloss measurements on the beaded system are displayed in Figures 22, 23, 24, 25 and 26. The mar-resistance and Weather-Ometer results of the beaded, Type II, Flash Dry system showed the same trend as with the Type I version.

2. Mil-E-52798A, Air Dry Alkyd Enamel

The techniques used to formulate Mil-E-52798A, Forest Green, are very similar to those used for the Mil-E-52929 formulation. Therefore, the 0.4 pounds per gallon level of clear vesiculated beads was substituted for all inerts in the conventional Mil-ES2798A formulation. As can be seen from the data, this level of beads brought the color and gloss into the limits required by the specification for both the Type I and Type II formulas. The conventional formulations for Mil-E-52798A, Forest Green, Type I and II are shown in Figures 27 and 28. The subsequent beaded formulations for Type I and Type II, as well as the resulting color and gloss data are provided in Figures 29 to 36.

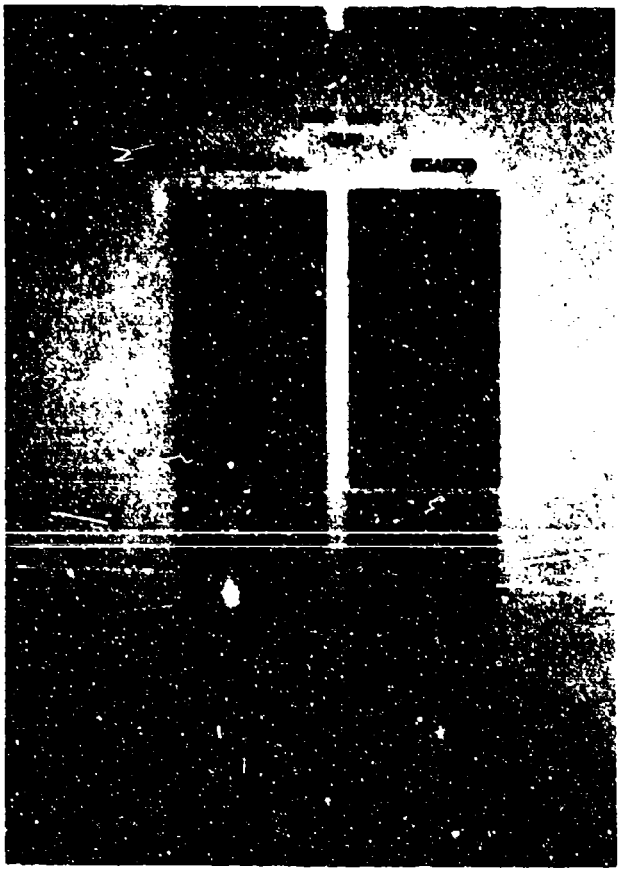
The final beaded formulations for Forest Green, Type I and Type II were then evaluated against the specification. Once again, the beaded coatings proved to have superior mar-resistance and weatherability to the conventional alkyd camouflage system. The photograph in Figure 37 shows panels of conventional and beaded Mil-E-52798A, Forest Green, Type I, after exposure in the Q-U-V Weather-Ometer for 300 and 500 hours. The conventional system again has a heavy white chalk-face while the beaded system more closely retains its original color characteristics. The weathering data for this series of panels is summarized in Figure 38.

3. Mil-C-46168A, Chemical Agent Resistant Urethane

The first point to be reconciled in formulating Mil-C-46168A with beads was whether the polymeric structure of the beads is resistant to the chemical decontaminant, DS_2. Samples of clear vesiculated and clear solid beads were submitted to Ft. Belvoir for DS_2 testing and found to be resistant to this harsh decontaminant. A sample of a vesiculated bead which was pigmented with an organic brown that was known to be susceptible to DS_2 attack was also submitted. When DS_2

FIGURE 37

MIL-E-52798A, ENAMEL ALKYD, FOREST GREEN, TYPE I,
300 HOUR AND 500 HOUR Q-U-V WEATHER-OMETER PANELS OF
CONVENTIONAL AND BEADED SYSTEMS



was applied to the organic brown bead the brown was dissolved from the inner walls of the vesiculated bead but the polymeric structure of the bead itself remained intact. Based on these results, it appears that in order to use a pigmented vesiculated bead in Mil-C-46168A, the pigment must be chemical-agent-resistant since the vesiculated structure of the bead allows the DS_2 to enter the bead and cannot protect the pigment.

The first step in formulating a Mil-C-46168A, Forest Green, Type I with clear vesiculated beads, was to replace all inerts with 0.4 pounds per gallon of polymeric beads. Since the urethane is a two-component system that is mixed four (4) parts A (Base) to one (1) Part B (Activator), it is necessary to remember that the 0.4 pounds per gallon bead level is based on a total mixed gallon of the two components. As with the beaded air dry alkyd and the flash dry alkyd systems, the beaded Mil-C-46168A Urethane, had better mar-resistance and weathering when compared to the conventionally formulated system. The conventional starting formulation that was used is shown in Figure 39 while the beaded version is listed in Figure 40. Color data on the beaded formulation is displayed in Figures 41, 42 and 43. Results of the weathering tests on Forest Green, Type I are included in Figure 44.

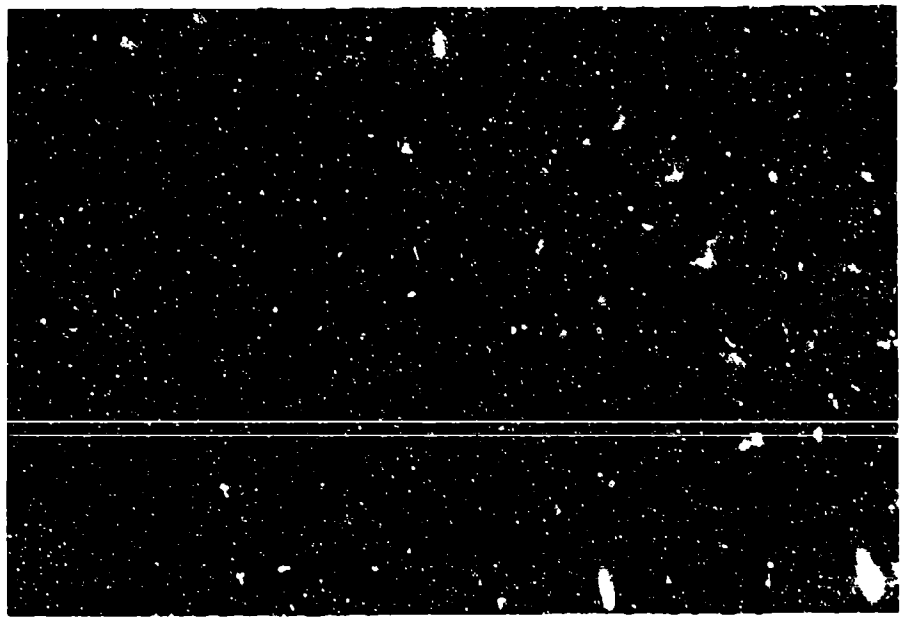
Other colors in the Mil-C-46168A quality that have been developed with clear vesiculated beads are: Forest Green (Type II), Black, Field Drab, Olive Drab (#34087), Sand, Insignia Blue, Aircraft White, Aircraft Black and Aircraft Green. In each case, a level of 0.4 to 0.45 pounds of beads was used per mixed gallon. The prime pigment ratios in some beaded formulas had to be altered slightly from the conventional formula in order to compensate for the increase in Cap "Y" that the vesiculated bead causes. Formulations and spectral data for each of the beaded colors mentioned above are given in Figures 45 through 62. Q-U-V weathering tests have not been completed on all of the beaded urethane colors at the time this report was issued. However, the photograph in Figure 63 displays results of 300 hour Q-U-V tests on the conventional and beaded Black and Field Drab formulations.

4. Mil-C-46168A, Clear Beaded Urethane Over Coat

The Army's decision to eventually require chemical-agent-resistant coatings (CARC) on all tactical equipment initiated the idea that perhaps a transparent, low-gloss, chemical-agent-resistant urethane could be developed to apply over conventional alkyd camouflage

FIGURE 63

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT, 300 HOUR Q-U-V WEATHER-OMETER PANELS OF FIELD DRAB AND BLACK CONVENTIONAL VS. BEADED SYSTEMS



coatings. This concept would make the coating system chemical-agent-resistant and would significantly reduce the cost of repainting vehicles in the field since a clear urethane over coat would be much less costly than a pigmented camouflage urethane.

The clear, low-gloss over coat concept could not be accomplished with conventional inerts since talcs and silicas would give the film a partially opaque appearance. However, clear vesiculated beads offered a possible formulation tool to achieve both the low-gloss and the transparency.

In our first experiment, we used 25 micron clear vesiculated beads, at a 0.57 pounds per admixed gallon level, in a clear Mil-C-46168A formulation. This coating was then applied at 0.5 mil DFT (dry film thickness) over a panel that had been coated with Mil-E-52798A, Forest Green Alkyd. The 25 micron clear vesiculated bead was not transparent enough, causing the total coating system to have slightly distorted color values.

The next set of experiments were conducted using a 10 micron clear vesiculated bead at a pound-for-pound replacement for the 25 micron bead in the clear urethane formulation. This system was also applied at 0.5 mils DFT over the Mil-E-52798A, Forest Green Alkyd. These results are summarized in Table 6.

The 10 micron clear vesiculated bead lowers the gloss and sheen into the required range and is transparent enough to permit the original camouflage color properties of the alkyd to show through the urethane coating.

The weathering of the total system of the clear beaded urethane, applied at 0.5 mils DFT over the Mil-E-52798A, Forest Green, Alkyd Enamel, was then evaluated. Panels of this system were exposed in the Q-U-V Weather-Ometer for 300, 400 and 500 hours. The conventional Mil-E-52798A was only exposed for 300 hours since the Cap "Y" had already changed so dramatically during that exposure period. Results of the exposure testing are summarized in Table 7.

The results, as indicated in Table 7, show that the clear beaded urethane over coat effectively minimizes the white chalk-face that normally occurs when a conventional alkyd is weathered.

Since the clear beaded urethane would be applied over a weathered finish when repainting a vehicle in the field, we felt it necessary to check the intercoat adhesion and the effect of the clear coating on color of the weathered finish. To make this determination, we exposed panels of Mil-E-52798A, Forest Green, Alkyd Enamel, in the Q-U-V Weather-Ometer for 200, 400 and 500 hours. We then sprayed 0.5 mils DFT of the clear beaded urethane over these exposed panels and checked color and gloss. This data is shown in Table 8.

From these results, one can see that the clear beaded urethane nearly returned the Cap "Y" of the exposed panel back to its original value. Also, there were no signs of intercoat adhesion failure between the clear urethane and the weathered alkyd coating.

Based on the above data, the concept of a clear, beaded urethane appears to be a very feasible approach for repainting vehicles in the field. This system is also currently being evaluated by Grumman as a clear over coat for stencils to make them chemical-agent-resistant. Initial test results by Grumman look very promising.

B. CLEAR SOLID BEADS

Based on the data obtained in Table 1, very little of our research time on this contract was spent investigating clear solid beads. In order to achieve the low gloss required for camouflage, we determined that five (5) times the level of solid beads were needed to achieve the same gloss level as with vesiculated beads. We felt that the high level of solid beads would be too cost-prohibitive for the Army's end-use assuming the solid and vesiculated beads are at equal cost.

One experiment we did conduct with clear solid beads was the addition of these beads to the Mil-C-46168A, Clear Urethane Over Coat. To the clear urethane, 1.25 pounds per admixed gallon of clear solid beads were added. At this level, the 60 degree gloss was still higher than required by the specification (Actual 2.6 -- Specification 1.0 maximum). This clear, solid beaded urethane coating was then sprayed at 0.5 mils DFT over a Mil-E-52798A, Air Dry Alkyd, Forest Green and exposed in the Q-U-V Weather-Ometer. Results of this weathering study are summarized in Table 9.

The data shown in Table 9 demonstrates that the clear solid beaded urethane over coat protects the conventional alkyd camouflage coating so that a white chalk-face will not occur upon weathering.

The clear solid beaded urethane had excellent mar-resistance. The intercoat adhesion between this urethane coating and the alkyd finish were also observed to be very good -- no adhesion loss was noted.

C. PIGMENTED BEADS FOR CAMOUFLAGE

The concept of a camouflage coating in which all the prime pigments and inerts are replaced with pigmented beads appeared to be a very logical use of bead technology. Theoretically, pigmented beads would lower gloss, improve mar-resistance, improve weatherability (due to removal of inerts), and hopefully reduce cost since the color properties of an expensive pigment such as cobalt would be maximized through encapsulation. However, the implementation of pigmented beads into camouflage coatings is far more complex than the implementation of clear beads due to the wide variety of pigments to be encapsulated and the subsequent color matching that would be required. Therefore, we tested the concept in our research - found it to be feasible - but did not pursue it in great depth at this time due to the immediate requirements for the clear polymeric beads.

In our work, we encapsulated a wide variety of pigments that are commonly used in camouflage formulations. These pigments are summarized in Table 10. Note that for many of the pigments we successfully produced both solid and vesiculated beads.

The last phase of our research with pigmented beads centered around the development of Mil-C-46168A, Chemical Agent Resistant Coating, Forest Green, Type I and Type II. In our initial experiment, a 25 micron cobalt vesiculated bead was used in the place of cobalt pigment and all inerts in a Mil-C-46168A, Forest Green, Type II. A small amount of a 25 micron bead containing diatomaceous silica was also used to help raise the 730 nm reading. The last formulation we worked with is displayed in Figure 64. The spectral data, color curve and color ellipse for this formulation are shown in Figures 65, 66 and 67 respectively.

The next experiment of significance was to replace all prime pigments and inerts in Mil-C-46168A, Forest Green, Type I, with pigmented beads. The most recent formula we developed is described in Figure 68. Note that only a cobalt vesiculated bead, chromium oxide vesiculated bead and an organic brown solid bead were used to develop a Forest Green color. The spectral data, color curve and color ellipse for this formula are shown in Figures 60, 70 and 71 respectively. While the 670 nm point is 0.25% higher than specification, the color is in a very shadeable position.

In our limited research with pigmented beads, we observed that the mar-resistance of the beaded coating was much improved over the conventional camouflage system as we previously observed with the clear vesiculated beaded systems.

SECTION VIII

CONCLUSIONS

The research conducted under contract DAAK 70-81-C-0126 indicates that polymeric bead technology can be successfully utilized in camouflage coatings systems. The experimental data indicates that conventional inerts can be replaced with clear vesiculated beads to achieve the very low gloss required for the MIL-E-52798A, Air Dry Alkyd; MIL-E-52929, Flash Dry Alkyd; and MIL-E-46168A, Chemical Agent Resistant Urethane camouflage specifications. By making this change, we observed that beaded camouflage coatings exhibited superior weather-resistance to conventional camouflage systems. It was also noted that beaded coatings have better mar-resistance which should allow them to be more easily cleaned than the standard camouflage coating.

A comparison of clear solid beads versus clear vesiculated beads showed that solid beads impart better mar-resistance but they are far less efficient at lowering gloss. The clear vesiculated beads also improve mar-resistance while efficiently reducing the gloss of the camouflage coating. Since approximately five times as many solid beads as vesiculated beads are required to achieve the same gloss, we concluded that it would not be as cost effective to develop a camouflage coating using solid beads as the sole raw material for gloss control. Clear vesiculated beads offer a means of lowering gloss while improving the mar-resistance and weathering-characteristics of the camouflage coating.

The concept of a clear, beaded, chemical-agent-resistant urethane, that can be applied over existing alkyd camouflage finishes, appears to be a viable alternative for refinishing tactical vehicles currently in use. Ten micron clear vesiculated beads must be used for gloss control in order for the urethane to have the necessary transparency. The clear, beaded urethane over coat does not distort the camouflage color properties of the original alkyd. The mar-resistance and durability of the clear over coat were found to be superior to the alkyd enamel.

A wide variety of pigments common to conventional camouflage formulations were encapsulated to form solid and vesiculated polymeric beads. A combination of these pigmented beads were

then utilized to produce a Forest Green camouflage coating that did not contain any inerts or prime pigments. While considerably more research needs to be completed on pigmented beads, the preliminary data discussed in this report indicates that this technology offers a viable approach to low gloss camouflage coatings that have improved mar-resistance, clearability and weather-resistance over the currently specified camouflage systems.

SECTION IX

RECOMMENDATIONS

As a result of the research we have performed, it is our recommendation that clear vesiculated beads be written into the three primary camouflage specifications:

- MIL-E-52798A, Air Dry Alkyd Enamel
- MIL-E-52929, Flash Dry Alkyd Enamel
- MIL-C-46168A, Chemical Agent Resistant Urethane.

In order to implement this recommendation, it will be necessary to write new specifications. A scale-up will also be required to make full-scale production quantities of dry, clear vesiculated beads and production quantities of beaded camouflage coatings in order that the polymeric bead technology can be successfully implemented.

The clear, beaded, urethane over coat concept also needs to be pursued. We suggest further work with the Army (or a designee of the Army) that would involve actually painting some weathered vehicles with this clear, beaded urethane to test restoration of color and gloss, chemical-agent-resistance, cleanability, mar-resistance and long-term weatherability.

We recommend that additional research be performed on the pigmented bead technology. Preliminary data indicates that Forest Green can be made using pigmented polymeric beads in the place of all prime pigments and inerts. Further testing needs to be completed to ensure reproducibility of both the pigmented beads themselves as well as reproducibility of the Forest Green color. Since the beaded Forest Green has only been made in the MIL-C-46168A quality, the same technology will have to be applied to the MIL-E52798A and MIL-E-52929 specifications. The other colors in the specifications will also have to be matched using pigmented polymeric beads. Additionally, the expected economies from utilization of pigmented polymeric beads needs to be evaluated.

We further recommend that the following areas concerning polymeric bead technology be explored:

- Investigate the possibility of incorporating slip additives such as silicones or waxes into the composition of the bead to further upgrade the mar-resistance of camouflage coatings

- Evaluate beads that are composed of polymers other than the current unsaturated polyester resin. For example, a bead made from acrylic resin could be more transparent, more durable and provide more mar-resistance to the film than our current bead structure.

- Investigate the encapsulation of corrosion-resistant pigments for application in anti-corrosive primer formulations

- Apply polymeric bead technology to high solids, VOC, compliance coating formulations.

APPENDIX A - TABLES

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TABLE 1

MIL-C-46168A, ALIPHATIC URETHANE, FOREST G.EEN,
COMPARISON OF CLEAR SOLID VS. CLEAR VESICULAT 'D BEADS

Sample Description	Pounds Beads per Admixed Gallon	60° Gloss	85° Gloss
Conventional (no beads)	0.00	0.8	1.8
Clear Vesiculated Beads	0.40	0.8	1.2
Solid Beads	0.45	30.3	40.3
Solid Beads	1.05	20.8	25.8
Solid Beads	1.50	12.7	19.8
Solid Beads	2.25	1.2	2.2

TABLE 2

TEST METHODS AND EQUIPMENT

Property	Fed. Std. 141 Test Method	Equipment Description
60 Degree Gloss	Method 6101	Hunter, Model A-1096
85 Degree Gloss	Method 6103	Hunter, Model A-1120
Color	Method 4251 & 6241	Diano-Hardy Match Scan II Model #600700G029 and Diano-Hardy Model #400016
Accelerated Weathering	Method 6122	Q-Panel Q-U-V Weather-Ometer Serial #80-805-05-21
Fineness of Grind	Method 4411	Hegman Gauge
Drying Time	Method 4061	
Mar-Resistance		Drag fingernail of constant pressure over beaded and conventional coating. Visually compare mar-resistance of the two films.
Bead Size Distribution		Elzone particle counter Model #112LTSD/ADC with Osciloscope Model #LBO-5111

TABLE 3

CONVENTIONAL CAMOUFLAGE COATING

V-3

TABLE 4

MIL-E-52929, FOREST GREEN,
COMPARISON OF VARIOUS CLEAR, VESICULATED BEAD LEVELS

Vii-2

TABLE 5

MIL-E-52929, FLASH DRY ALKYD ENAMEL, FOREST GREEN, BEADED
WETTING AGENT STUDY

Wetting Agents	% Wetting Agent Agent Based on Total Formuia by Weight	Cap "Y"	670	730
Control - No Wetting Agent - Unshaded		11.9	12.19	34.04
Nuosperse 657	1%	11.67	11.97	33.68
Nuosperse 657	2%	11.63	11.98	33.25
Nuosperse 657	3%	11.69	12.03	33.75
42% Solution SF-1023(Silicone)	0.25%	11.71	12.05	33.74
42% Solution SF-1023(Silicone)	0.5%	11.99	12.33	34.27
42% Solution SF-1023(Silicone)	0.75%	11.91	12.22	33.90
Yelkin TTS	1.%	11.74	12.11	32.95
Yelkin TTS	2.%	11.96	12.38	33.57
Yelkin TTS	3.%	12.07	12.4	33.42
BYK 104S	0.25%	11.69	11.69	33.55
BYK 104S	0.75%	11.86	12.03	33.53
BYK 104S	1.25%	11.76	11.98	33.40
50% Solution (Modaflow)	0.5%	11.71	12.03	33.72
50% Solution (Modaflow)	0.75%	11.41	11.79	33.24
50% Solution (Modaflow)	1.0%	11.71	12.07	33.97
Liquid Anti-Float (Troy)	0.25%	11.78	12.14	33.98
Liquid Anti-Float (Troy)	0.50%	11.79	12.23	33.98
Liquid Anti-Float (Troy)	0.75%	11.85	12.17	33.52
2-Amino-2-Methyl-1-Propanol(AMP-95%)	2.%	11.00	11.33	32.06
2-Amino-2-Methyl-1-Propanol(AMP-95%)	3.%	10.97	11.26	31.16
2-Amino-2-Methyl-1-Propanol(AMP-95%)	4.%	10.79	11.07	30.40
Lactimon (BYK)	0.5%	11.91	12.19	33.47
Lactimon (BYK)	1.0%	11.58	11.93	33.14
Lactimon (BYK)	1.5%	11.63	11.97	33.24

TABLE 6

COLOR READINGS OF 10 MICRON CLEAR BEADED URETHANE OVER MIL-E-52798A, ALKYD

Sample Description	670 NM	730 NM	x	y	z	Lx	Ly	Gloss 60°	Gloss 85°
Mil-E-52798A, Forest Green - no over coat	10.07	25.69	6.79	7.16	6.36	0.3343	0.3525	0.1	1.4
Mil-E-52798A, Forest Green, top coated with 10 micron vesiculated beaded clear urethane	9.84	24.80	7.03	7.42	6.95	0.3283	0.3468	0.1	2.6

TABLE 7

Q-U-V WEATHER-OMETER RESULTS
CLEAR VESICULATED BEADED URETHANE OVER MIL-E-52798A, ALKYD

Exposure Hours	300	400	500
Mil-E-52798A, Forest Green, Conventional			
Cap "Y" - Unexposed	7.22	-	-
Cap "Y" - Exposed	10.51	-	-
Percent Change	+45%	-	-
Mil-E-52798A, Forest Green, top coated with clear, 10 micron vesiculated beaded urethane			
Cap "Y" - Unexposed	7.78	7.42	7.55
Cap "Y" - Exposed	8.52	9.29	8.55
Percent Change	+9.5%	+25.2%	+13.2%

TABLE 9

Q-U-V WEATHER-OMETER RESULTS
CLEAR SOLID BEADED URETHANE OVER MIL-E-52798A, ALKYD

Exposure Hours	300	400	500
Mil-E-52798A, Forest Green, Conventional			
Cap "Y" - Unexposed	7.22	-	-
Cap "Y" - Exposed	10.51	-	-
Percent Change	+45%	-	-
Mil-E-52798A, Forest Green, top coated with clear solid beaded urethane			
Cap "Y" - Unexposed	8.02	8.17	8.20
Cap "Y" - Exposed	8.26	8.28	8.31
Percent Change	+3.0%	+1.3%	+1.4%

TABLE 8

COLOR READINGS OF 10 MICRON CLEAR BEADED URETHANE COATED OVER EXPOSED MIL-E-52798A

	Initial			Exposed			Exposed Then Coated With Clear Beaded Urethane		
	Cap "Y"	60°	85°	Cap "Y"	60°	85°			
900G002 - @ 200 Hours	7.35	0.6	1.8	7.33	0.0	0.7	8.09	1.6	2.5
900G002 - @ 400 Hours	7.37	0.0	2.1	10.06	0.1	0.7	7.89	1.5	3.0
900G002 - @ 500 Hours	7.4	0.0	1.8	10.89	0.1	1.0	8.04	1.3	2.7

TABLE 10

PIGMENTS ENCAPSULATED FOR USE IN CAMOUFLAGE COATINGS

Sample No.	Pigment	Bead Size	Bead Type
325B2	Organic Maroon	25 Micron	Solid
325B3	Carbazole Violet	25 Micron	Solid
325B4	Organic Yellow	25 Micron	Solid
325B5	Organic Maroon	25 Micron	Vesiculated
325B7	Organic Brown	25 Micron	Solid
325B8	Organic Brown	25 Micron	Vesiculated
325B11	Organic Yellow	25 Micron	Vesiculated
325B20	Amorphous-Synthetic Silica	25 Micron	Solid
325B21	Silicate	10 Micron	Vesiculated
325B22	Silicate	10 Micron	Solid
325B31	Chrome Oxide	25 Micron	Vesiculated
325B33	Magnesium Silicate	25 Micron	Vesiculated
325B34	Silica-Diatomacous	25 Micron	Vesiculated
325B35	Chrome Medium Yellow	25 Micron	Vesiculated
325B36	Chrome Medium Yellow	25 Micron	Solid
325B37	Titanium-Exterior Grade	25 Micron	Vesiculated
325B40	Molybdate Orange	25 Micron	Vesiculated
325B48	Magnesium Silicate	10 Micron	Vesiculated
325B50	Inorganic Black	25 Micron	Vesiculated
325B51	Inorganic Brown	25 Micron	Vesiculated
325B52	Inorganic Yellow	25 Micron	Vesiculated
325B53	Inorganic Green	25 Micron	Vesiculated
325B54	Inorganic Brown	25 Micron	Vesiculated

TABLE 10

PIGMENTS ENCAPSULATED FOR USE IN CAMOUFLAGE COATINGS (CON'T.)

Sample No.	Pigment	Bead Size	Bead Type
325B55	Inorganic Blue	25 Micron	Vesiculated
325B57	Inorganic Yellow	25 Micron	Vesiculated
325B58	Strontium Chromate	25 Micron	Vesiculated
325B62	Cobalt Blue	25 Micron	Vesiculated
325B80	Silica-Diatomaceous	10 Micron	Vesiculated
325B84	Molybdate Orange	25 Micron	Solid
325B88	Cobalt Green	25 Micron	Solid
325B92	Cobalt Green	25 Micron	Vesiculated
325B94	Yellow Oxide	25 Micron	Vesiculated
325B95	Red Oxide	25 Micron	Vesiculated
325B97	Red Oxide	25 Micron	Solid

APPENDIX B - FIGURES

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APPENDIX B - FIGURES

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APPENDIX B - FIGURES

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APPENDIX B - FIGURES

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APPENDIX B - FIGURES

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FIGURE 1

25 MICRON (TOP-SIZE) TITANIUM VESICULATED BEADS

V-3

FIGURE 2

AN 11 MICRON TITANIUM VESICULATED BEAD

V-3

FIGURE 3

CROSS-SECTION OF AN 11 MICRON TITANIUM VES CULATED BEAD

V-4

FIGURE 4

MIL-E-52929, ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY,
FOREST GREEN, TYPE I
CONVENTIONAL STANDARD FORMULA

	Pounds	Gallons
PREMIX AND GRIND		
Mineral Spirits	44.70	6.86
Bentone 34	9.69	0.50
Diacetone Alcohol	3.40	0.45
60% Wt. Med-Short Phenolic Modified Alkyd - Volume Solids 51%	182.39	22.17
Anti-Skin	0.88	0.11
Magnesium Silicate	135.79	5.72
Cobalt Green	87.29	2.01
Chromium Oxide	113.48	2.66
Med. Chrome Yellow	9.69	0.20
Molybdate Orange	14.54	0.29
COVER FOR PREMIX		
Mineral Spirits	5.92	0.94
SAND MILL TO #4 GRIND		
1ST MILL WASH		
60% Wt. Med-Short Phenolic Modified Alkyd - Volume Solids 51%	24.18	2.94
Isoprophyl Alcohol (99%)	12.41	1.91
2ND MILL WASH		
Mineral Spirits	14.32	2.20
SIFT IN AND AGITATE TO #4 GRIND		
Diatomaceous Silica	72.74	3.78
THEN REDUCE THE FOLLOWING		
60% Wt. Med-Short Phenolic Modified Alkyd - Volume Solids 51%	148.39	18.15
Toluol	52.66	7.26
Isopropyl Alcohol 99%	38.58	5.93
Mineral Spirits	75.51	11.60
Anti-Skin	0.89	0.11
Lead Drier 36%	1.86	0.16
Calcium Drier 6%	3.23	0.43
Cobalt Drier 12%	0.99	0.11
Manganese Drier 9%	0.90	0.11
Anti-Skin	11.65	1.46

Continued . . . .

FIGURE 4

MIL-E-52929, ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY,
FOREST GREEN, TYPE I
CONVENTIONAL STANDARD FORMULA (CON'T.)

	Pounds	Gallons
HOLD FOR SHADING AND GLOSS		
Maroon - Shading Paste	11.65	1.46
Diatomaceous Silica	9.69	0.50
TOTAL	11,087.35	100.00

Theoretical Weight per Gallon = 10.87
Volume Solids = 42.5
Weight Solids = 64.4

FIGURE 5

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-E-52929, ENAMEL ALKYD CAMOUFLAGE, FLASH DRY, TYPE 1,
CONVENTIONAL STANDARD FORMULA

Wave Length	670	730
% Reflectance/Transmittance	9.66	27.1

	x	y	z	Lx	Ly
Color Measurements	6.62	7.03	6.37	0.3308	0.3511

	% Reflectance/Transmittance
Infrared Reflectance Average	47.508
Visible Near-Red Reflectance Average	8.006
Ratio Visible/Infrared	5.93

60 Degree Gloss	0.2
85 Degree Gloss	1.5

FIGURE 6

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH

MIL-E-52929 ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I
CONVENTIONAL STANDARD FORMULATION

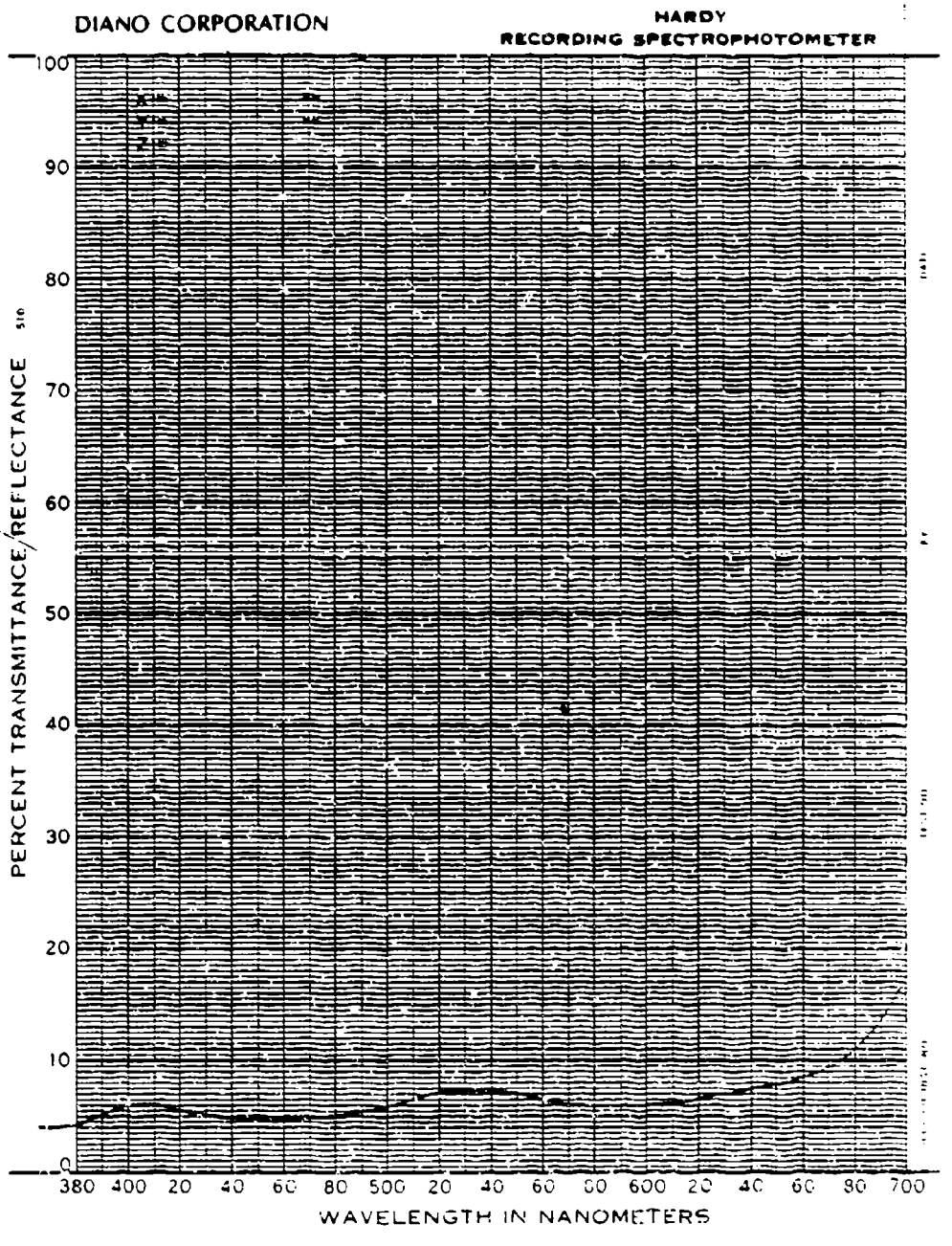

FIGURE 7

MIL-E-52929 ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I
CONVENTIONAL STANDARD FORMULATION

"Y" (B R I G H T N E S S) - . 0 5 8 - . 0 7 5

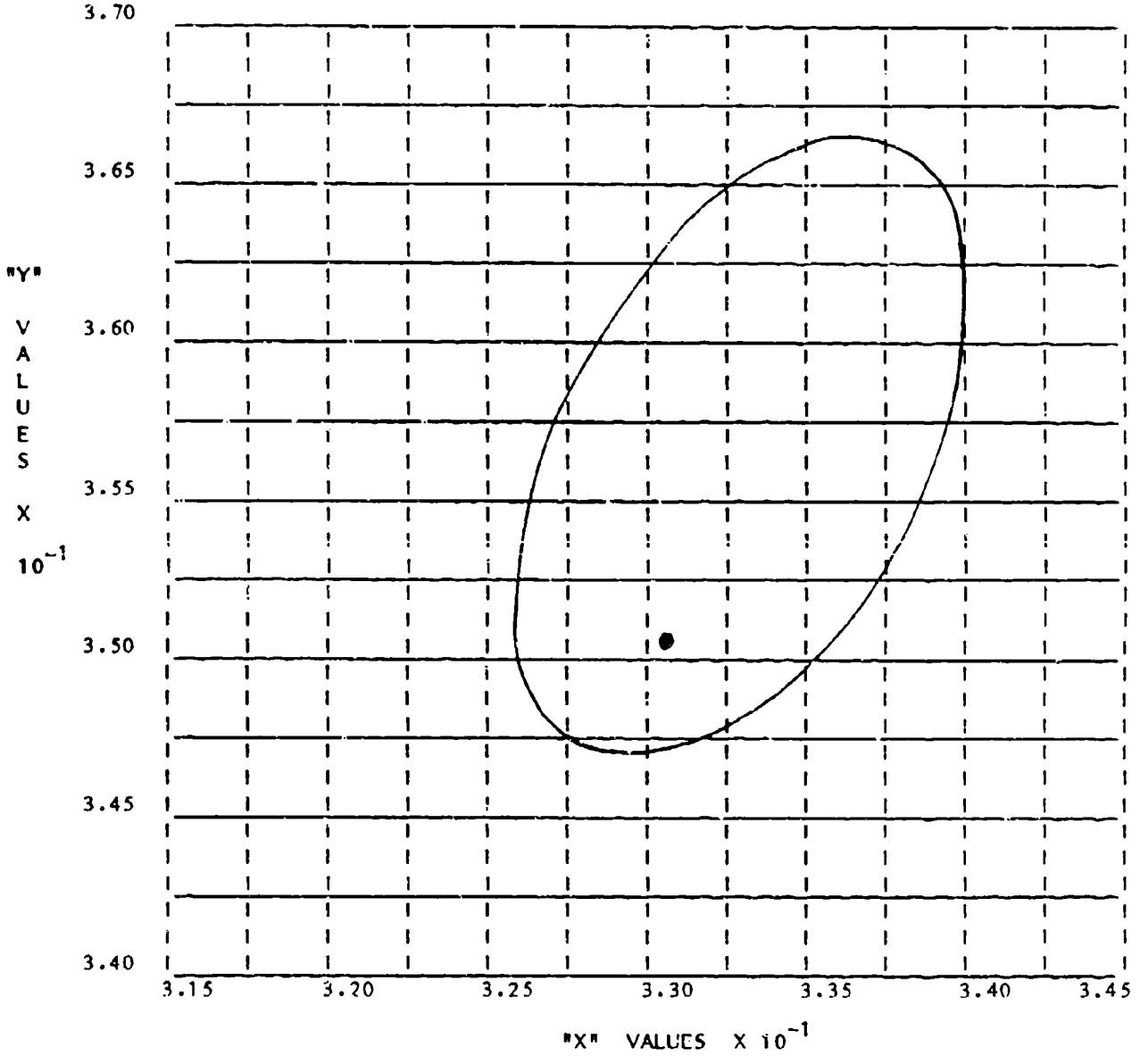

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS
UNITS FROM CENTER VALUES

| X - 2795 |

FIGURE 8

MIL-E-52929, BEADED, ALKYD ENAMEL, FLASH DRY,
FOREST GREEN, TYPE I
INITIAL FORMULATION -- TWO-STEP DISPERSION

	Pounds	Gallons
Mineral Spirits	45.53	6.99
Bentone 34	9.88	0.51
Diacetone Alcohol	3.47	0.45
60% Wt. Med.-Short Phenolic Modified Alkyd - Volume Solids 51%	185.87	22.58
Anti-Skin	0.89	0.12
Cobalt Green	88.92	1.97
Chromium Oxide	115.60	2.71
Medium Chrome Yellow	9.88	0.20
Molybdate Orange	14.82	0.29
SAND MILL THE ABOVE TO 7 N.S.		
LET DOWN		
60% Wt. Med.-Short Phenolic Modified Alkyd - Volume Solids 51%	179.78	21.85
Isopropyl Alcohol	51.94	7.98
Mineral Spirits	97.54	14.97
Toluol	53.64	7.40
Anti-Skin	0.88	0.12
Lead Drier 36%	1.89	0.17
Calcium Drier 6%	3.29	0.45
Cobalt Dried 12%	1.00	0.12
Manganese Drier 9%	0.92	0.12
	861.74	88.47
SIFT IN THE FOLLOWING RAW MATERIAL - SAND MILL TO 4 N.S.		
25 Micron Clear Vesiculated Bead	38.12	11.21
TOTAL	903.86	100.00

Theoretical Weight per Gallon = 9.02
Volume Solids = 39%
Weight Solids = 53.8

FIGURE 9

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-E-52929 ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I
INITIAL BEADED FORMULATION -- TWO-STEP DISPERSION

Wave Length	670	730
% Reflectance/Transmittance	10.28	26.36

	x	y	z	Lx	Ly
Color Measurements	6.98	7.35	6.70	0.3320	0.3495

	% Reflectance/Transmittance
Infrared Reflectance Average	45.604
Visible Near-Red Reflectance Average	8.288
Ratio Visible/Infrared	5.50

50 Degree Gloss	0.4
85 Degree Gloss	0.9

FIGURE 10

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH

MIL-E-52929, ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I
INITIAL BEADED FORMULATION -- TWO-STEP DISPERSION

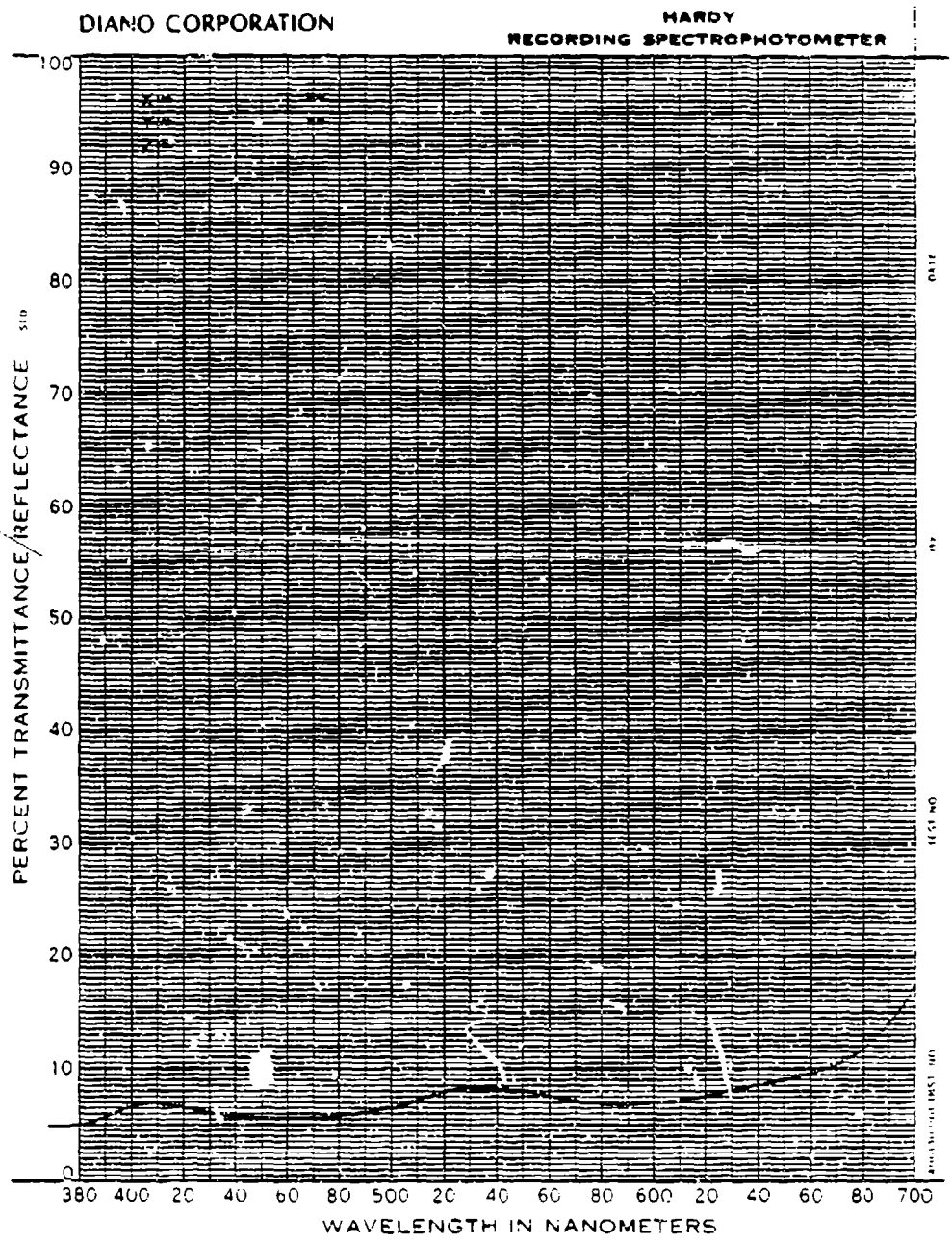

FIGURE 11

MIL-E-52929 ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I
INITIAL BEADED FORMULATION -- TWO-STEP DISPERSION

"Y" (B R I G H T N E S S) - . 0 5 8 - . 0 7 5

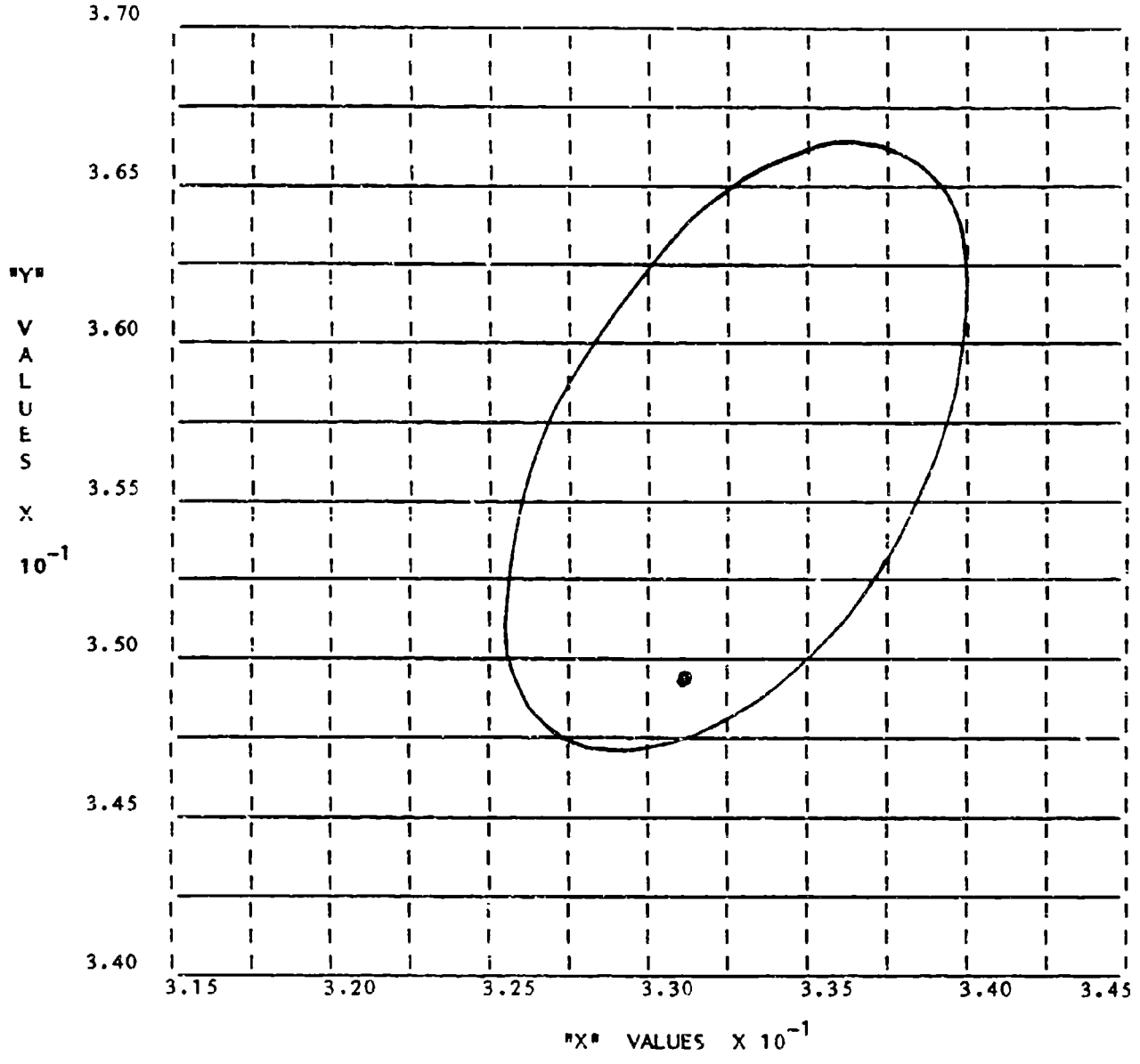

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS
UNITS FROM CENTER VALUES

X - 2795

FIGURE 12

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-E-52929, ALKYD CAMOUFLAGE ENAMEL, FLASH DRY, TYPE I
INITIAL FORMULATION (10 MICRON BEADS)

Wave Length	670	730
% Reflectance/Transmittance	10.37	33.89

	x	y	z	Lx	Ly
Color Measurements	9.22	10.95	9.18	0.314041	0.37316

	% Reflectance/Transmittance
Infrared Reflectance Average	51.87
Visible Near-Red Reflectance Average	9.46
Ratio Visible/Infrared	5.48

60 Degree Gloss	6.0
85 Degree Gloss	6.7

FIGURE 13

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH

MIL-E-52929, ALKYD, CAMOUFLAGE ENAMEL, FLASH DRY, TYPE I
INITIAL FORMULATION (10 MICRON BEADS)

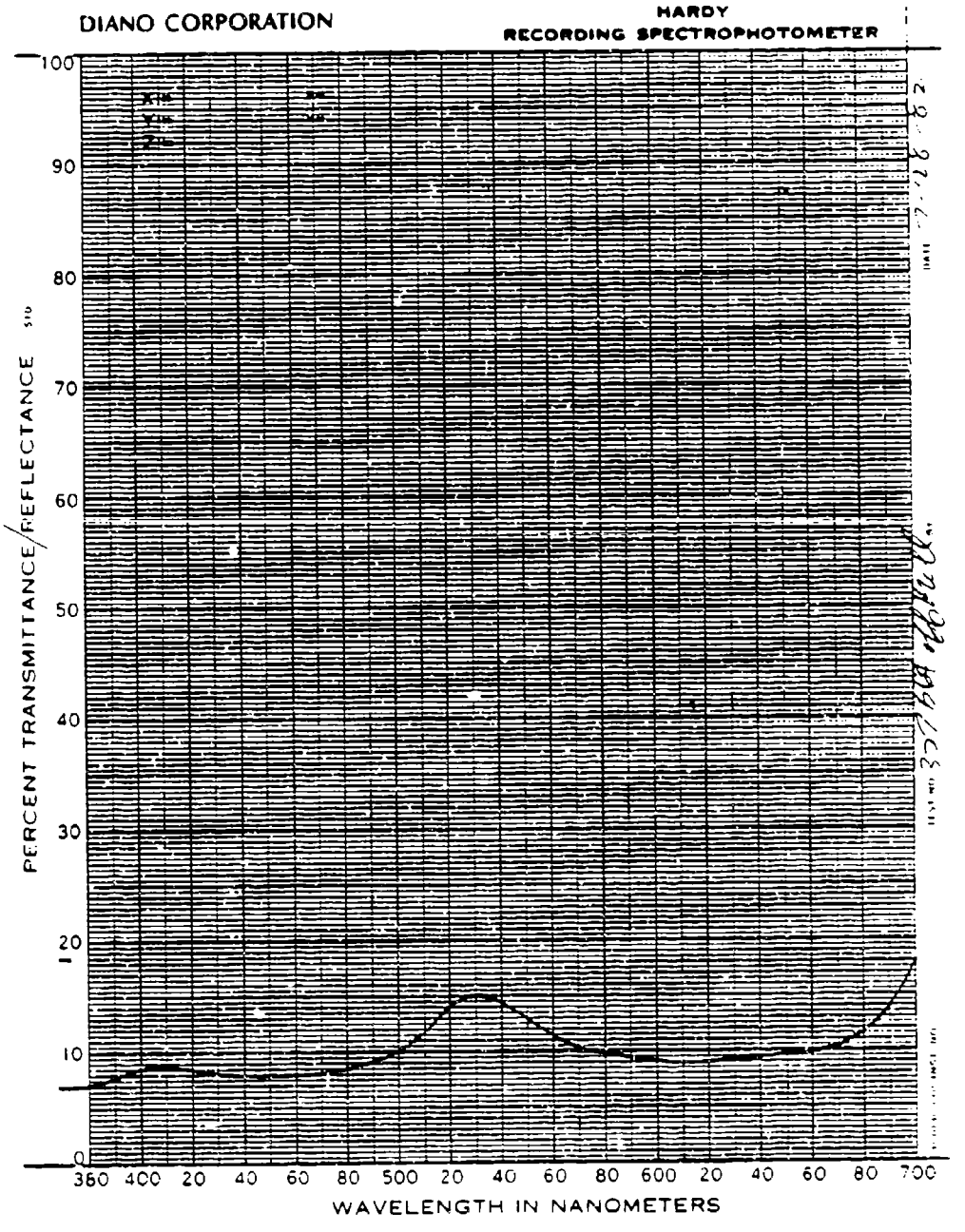

FIGURE 14

MIL-E-52929 ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I
INITIAL FORMULATION (10 MICRON BEADS)

"Y" (BRIGHTNESS) - .058 - .075

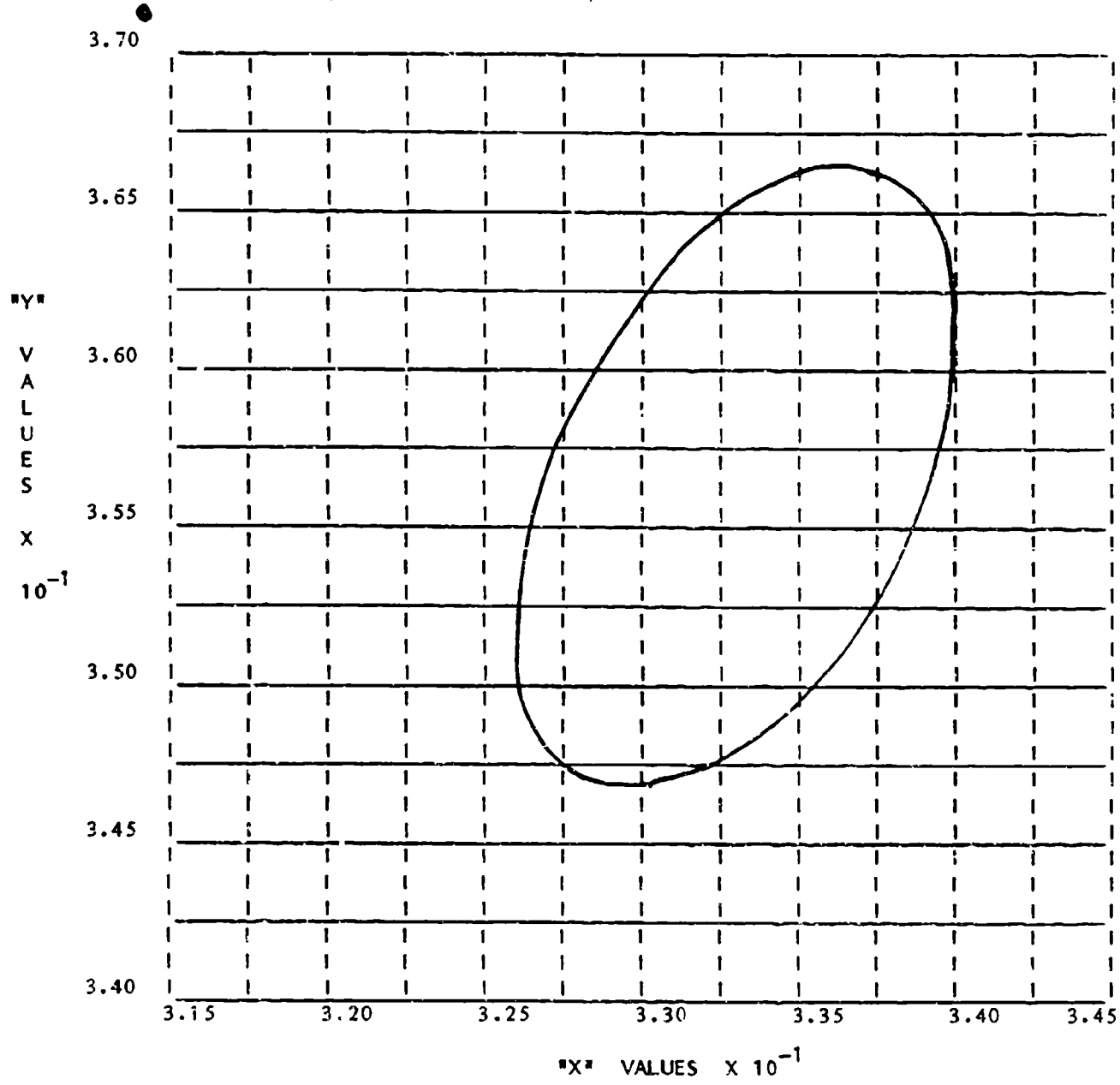

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS
UNITS FROM CENTER VALUES

X - 2795

FIGURE 15

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-E-52929, ALKYD CAMOUFLAGE ENAMEL, FLASH DRY, TYPE I
FINAL BEADED FORMULATION

Wave Length	570	730
% Reflectance/Transmittance	9.08	29.10

	x	y	z	Lx	Ly
Color Measurements	6.63	7.07	6.47	0.328551	0.35070

	% Reflectance/Transmittance
Infrared Reflectance Average	46.88
Visible Near-Red Reflectance Average	7.98
Ratio Visible/Infrared	5.87

60 Degree Gloss	0.4
85 Degree Gloss	1.8

FIGURE 16

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH

MIL-E-52929, ALKYD CAMOUFLAGE ENAMEL, FLASH DRY, TYPE I
FINAL BEADED FORMULATION

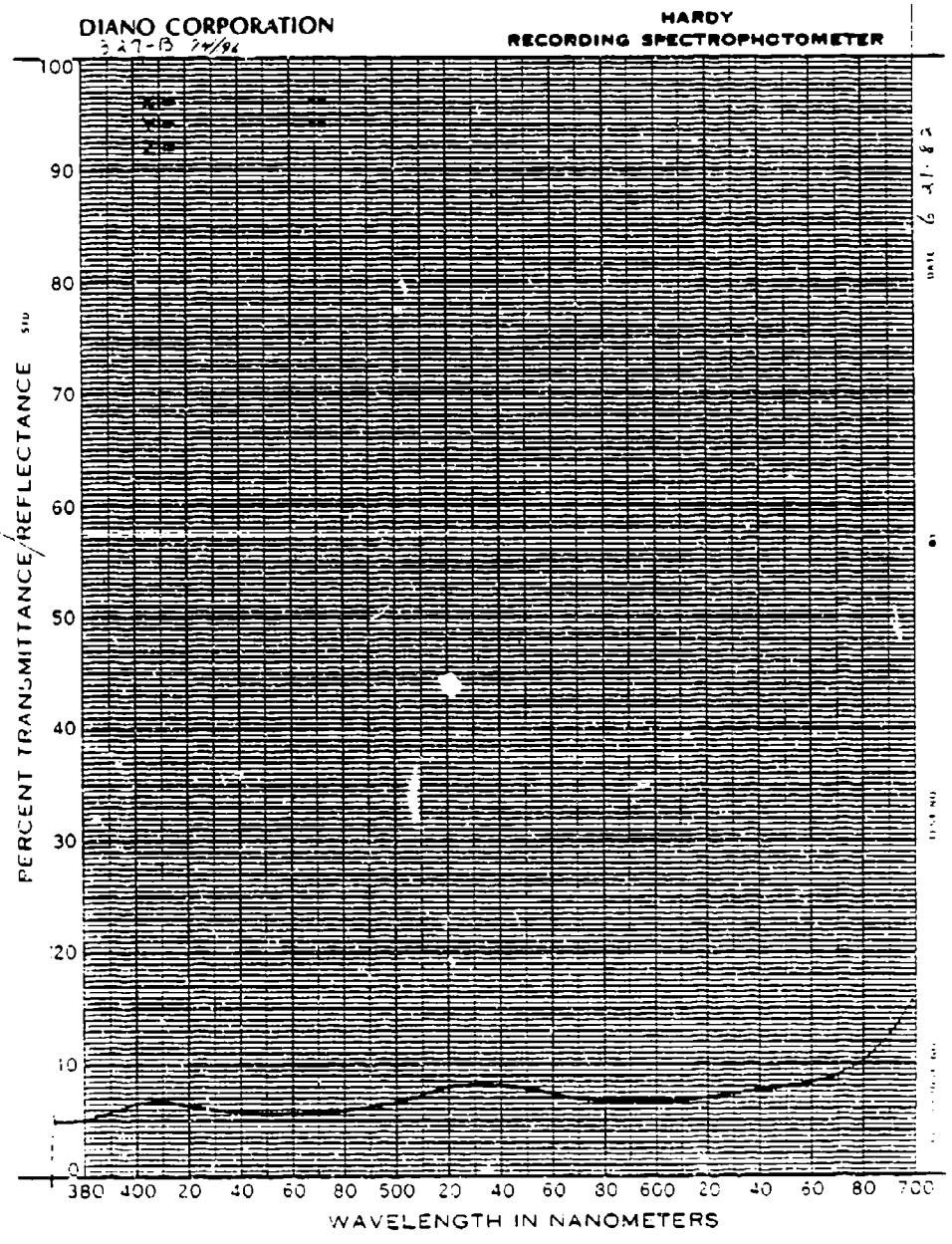

FIGURE 17

MIL-E-52929 ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I
FINAL BEADED FORMULATION

"Y" (BRIGHTNESS) - .058 - .075

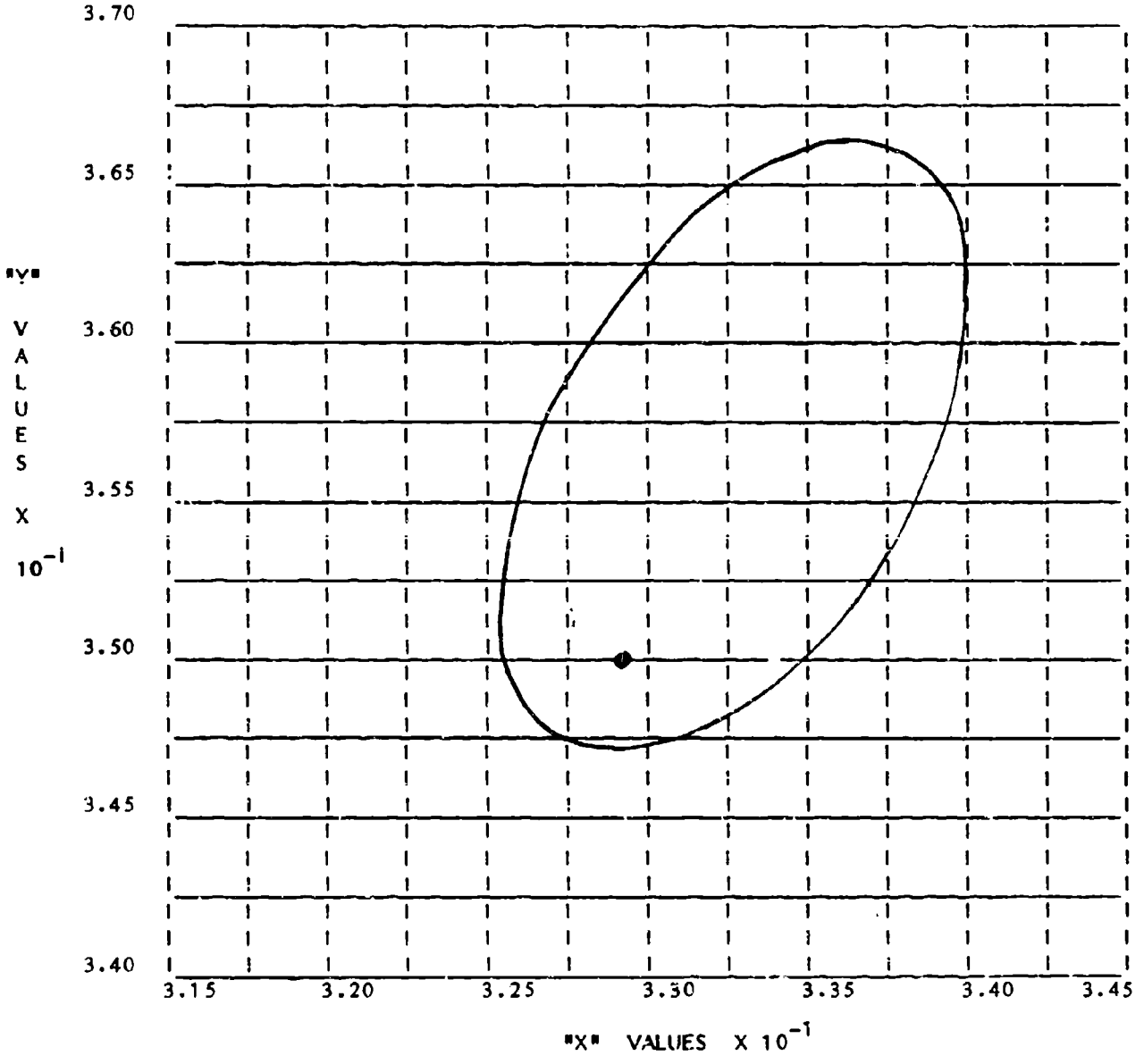

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS
UNITS FROM CENTER VALUES

X - 2795

FIGURE 18

MIL-E-52929, BEADED FLASH DRY ALKYD,
FOREST GREEN, TYPE I
FINAL OFF-MILL FORMULATION

	Pounds	Gallons
Mineral Spirits	45.43	6.98
Bentone #14	9.86	0.51
Diacetone Alcohol	3.47	0.44
Isopropyl Alcohol	11.26	1.73
60% Wt. Alkyd Resin - Volume Solids 51%	251.26	30.52
Anti-Skinning Agent	0.90	0.12
Mineral Spirits	19.72	3.06
Cobalt Green	108.47	2.50
Chromium Oxide	95.65	2.25
Medium Chrome Yellow	9.86	0.21
Molybdate Orange	14.79	0.39
25 Micron Clear Vesiculated Beads	39.44	11.59
Toluol	23.00	3.18
SAND MILL THE ABOVE TO 4 N.S.		
LET DOWN		
60% Wt. Alkyd Resin - Volume Solids 51%	109.64	13.32
Toluol	30.51	4.22
Mineral Spirits	76.79	11.81
Isopropyl Alcohol	40.56	6.23
Anti-Skinning Agent	0.88	0.11
Lead Drier 36%	1.89	0.16
Calcium Drier 6%	3.29	0.43
Cobalt Drier 12%	1.00	0.12
Manganese Drier 9%	0.92	0.11
TOTAL	898.59	100.00

Theoretical Weight per Gallon = 8.98
Volume Solids = 39%
Weight Solids = 55%

FIGURE 19

MIL-E-52929, ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I,
MAR-RESISTANCE COMPARISON OF CONVENTIONAL VERSUS BEADED SYSTEM

VII-4

FIGURE 20

MIL-E-52929, ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE I,
300 HOUR, Q-U-V WEATHER-OMETER EXPOSURE PANELS OF
CONVENTIONAL AND BEADED SYSTEMS

VII-5

FIGURE 21

SUMMARY OF Q-U-V WEATHER-OMETER MEASUREMENTS

COMPARISON OF MIL-E-52929, FOREST GREEN, TYPE I, BEADED VERSUS CONVENTIONAL

Sample	HRS QUV Exposure	670 NM	720 NM	Cap "Y"	Lx	Ly	Gloss 60°	Gloss 85°
Conventional	0	9.76	29.26	7.05	0.331	0.352	0.4	1.1
	25	9.74	29.17	7.05	0.330	0.351	–	–
	50	9.78	29.10	7.13	0.330	0.351	–	–
	75	9.83	28.98	7.23	0.329	0.350	–	–
	150	11.55	29.97	9.16	0.323	0.343	–	–
	300	13.00	31.51	10.43	0.322	0.343	0.4	0.8
	500	14.68	33.50	12.02	0.320	0.342	0.4	0.8
Beaded	0	9.08	28.95	7.07	0.328	0.350	0.3	0.7
	25	8.91	28.41	7.04	0.327	0.350	–	–
	50	9.01	28.35	7.15	0.327	0.349	–	–
	75	9.02	28.36	7.16	0.327	0.349	–	–
	150	9.24	28.30	7.50	0.326	0.349	–	–
	300	9.07	28.64	7.36	0.324	0.352	0.1	0.4
	500	9.17	28.24	7.64	0.321	0.352	0.1	0.4

FIGURE 22

MIL-E-52929, FLASH DRY ALKYD,
FOREST GREEN, TYPE II
CONVENTIONAL STANDARD FORMULA

	Pounds	Gallons
Mineral Spirits	108.92	16.73
Toluol	28.13	3.88
Bentone 34	8.73	0.58
Diacetone Alcohol	1.51	0.19
60% Wt. Alkyd Resin - Volume Solids 51%	159.66	19.40
Exkin #2	1.32	0.17
Magnesium Silicate	9.60	4.04
Chromium Oxide	128.52	3.00
Cobalt Green	83.81	1.93
Organic Brown	12.00	0.96
Mineral Spirits	6.31	0.97
SAND MILL TO 5 N.S.		
LET DOWN		
60% Wt. Alkyd Resin - Volume Solids 51%	174.50	21.33
Mineral Spirits	12.62	1.94
Toluol	14.00	1.94
Diatomaceous Silica	97.00	5.04
Isopropyl Alcohol	80.38	12.36
Exkin #2	1.32	0.17
Calcium Drier 6%	2.51	0.33
Cobalt Drier 12%	1.24	0.14
Zirco Drier 12%	3.61	0.44
Toluol	21.00	2.90
Diatomaceous Silica	6.79	0.35
Carbazole Violet Shading Paste	9.06	1.21
TOTAL	1,058.94	100.00

Theoretical Weight per Gallon = 10.59
Volume Solids = 37.5%
Weight Solids = 60.0%

FIGURE 23

MIL-E-52929, BEADED FLASH DRY ALKYD,
FOREST GREEN, TYPE II
FINAL OFF-MILL FORMULATION

	Pounds	Gallons
Ethyl Cellosolve	86.19	11.13
Bentone #14	9.70	0.50
Diacetone Alcohol	1.66	0.21
60% Wt. Alkyd Resin - Volume Solids 51%	203.25	24.69
Exkin #2	1.26	0.16
Cobalt Green	121.35	2.80
Chromium Oxide	75.23	1.76
Organic Brown	14.56	1.17
Organic Yellow	12.13	0.98
25 Micron Clear Vesiculated Beads	48.54	14.27
SAND MILL THE ABOVE TO 4 N.S. GRIND		
LET DOWN		
60% Wt. Alkyd Resin - Volume Solids 51%	162.02	19.76
Ethyl Cellosolve	95.42	12.32
Isopropyl Alcohol	16.97	2.61
Toluol	47.30	6.56
Calcium Drier 6%	2.37	0.32
Cobalt Drier 12%	1.24	0.15
Zirco Drier 12%	3.70	0.45
Exkin #2	1.26	0.16
TOTAL	904.15	100.00

Theoretical Weight per Gallon = 9.04
Volume Solids = 44%
Weight Solids = 55%

FIGURE 24

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-E-52929, ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE II
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	7.76	27.06

	x	y	z	Lx	Ly
Color Measurements	6.23	6.75	5.87	0.330541	0.35786

	% Reflectance/Transmittance
Infrared Reflectance Average	43.0
Visible Near-Red Reflectance Average	6 95
Ratio Visible/Infrared	6.18

60 Degree Gloss	0.3
85 Degree Gloss	1.7

FIGURE 25

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH

MIL-E-52929, ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE II
FINAL BEADED FORMULATION

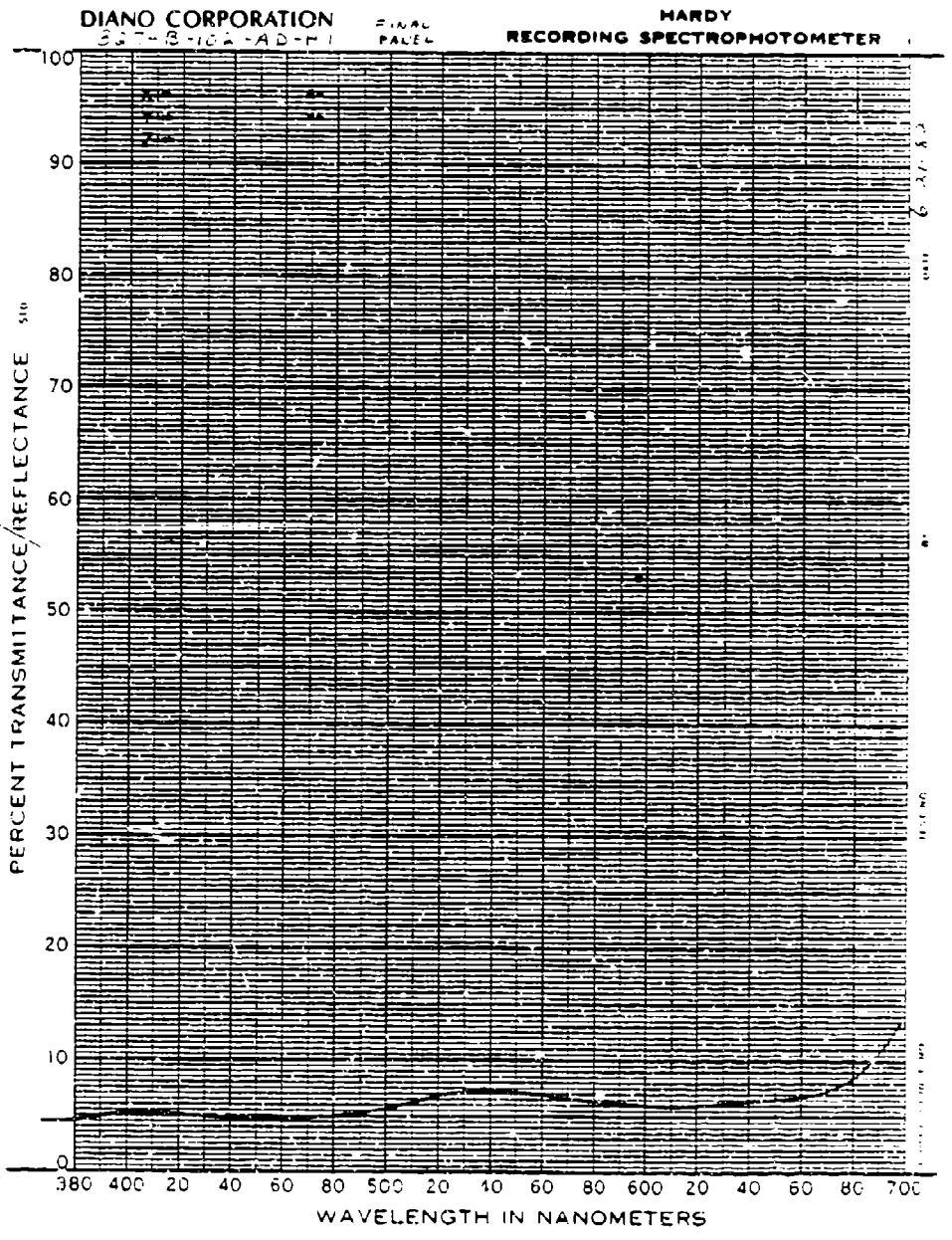

FIGURE 26

MIL-E-52929 ENAMEL, ALKYD CAMOUFLAGE, FLASH DRY, TYPE II
FINAL BEADED FORMULATION

"Y" (B R I G H T N E S S) - . 0 5 8 - . 0 7 5

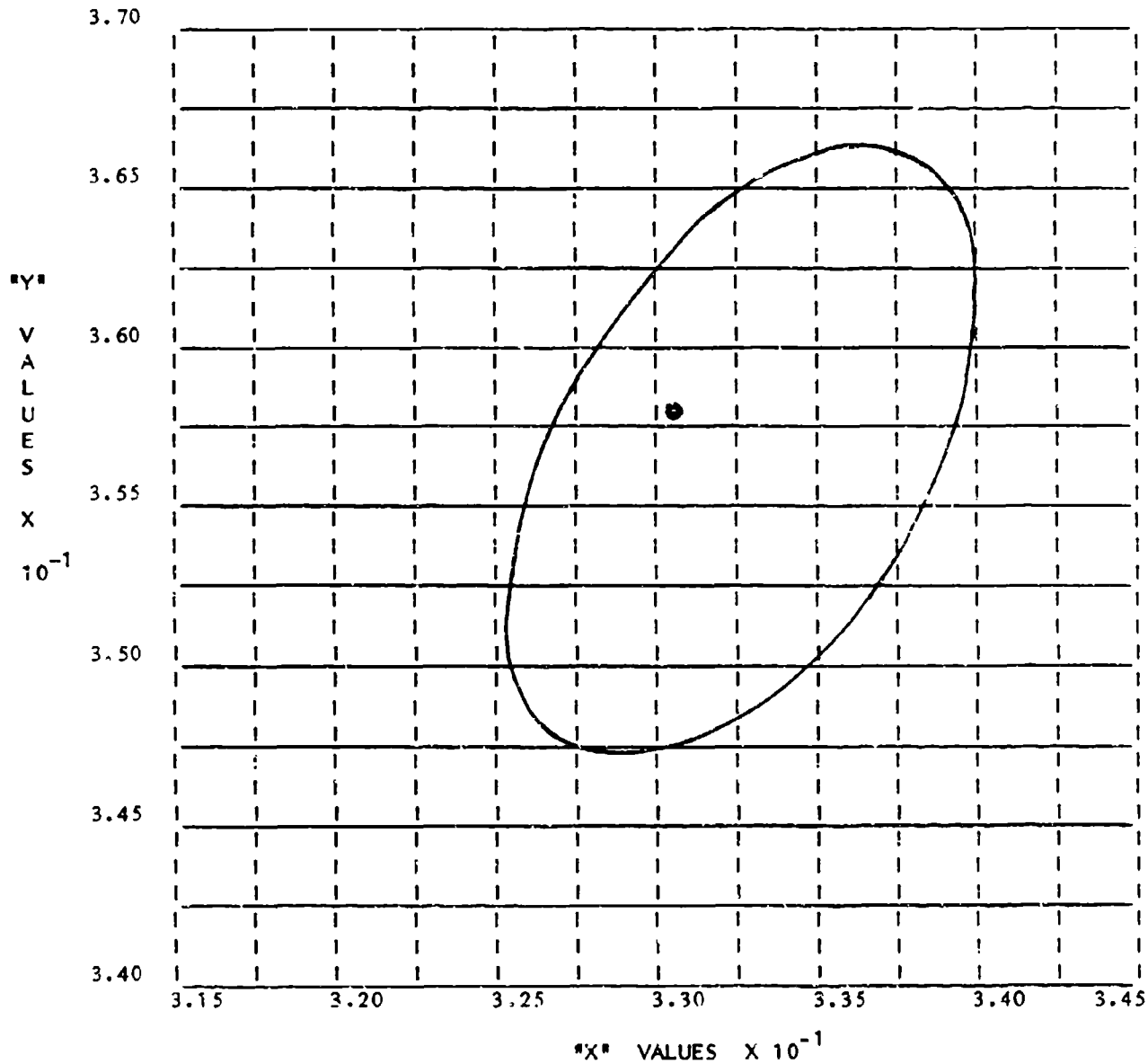

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS
UNITS FROM CENTER VALUES

X - 2795

FIGURE 27

MIL-E-52798A, ENAMEL ALKYD, FOREST GREEN, TYPE I
CONVENTION STANDARD FORMULATION

	Pounds	Gallons
Mineral Spirits	65.97	10.13
Bentone 38	8.53	0.60
PREMIX AND GRIND		
Diacetone Alcohol	2.50	0.32
MIX UNTIL PASTE GELS, THEN ADD		
50% Wt. Med. Alkyd - Volume Solids 41%	299.13	39.05
Anti-Skin	0.96	0.12
Magnesium Silicate	76.14	3.21
Zinc Phosphate	60.00	2.28
Cobalt Green	75.36	1.73
Chromium Oxide	113.97	2.67
Medium Chrome Yellow	3.59	0.30
Molybdate Orange	19.40	0.40
COVER FOR PREMIX		
Mineral Spirits	5.49	0.84
SAND MILL TO #5 GRIND - 1ST MILL WASH		
50% Wt. Med. Alkyd - Volume Solids 41%	16.18	2.11
Mineral Spirits	13.76	2.11
2ND MILL WASH		
Mineral Spirits	13.76	2.11
SHIFT IN AND AGITATE TO #5 GRIND		
Diatomaceous Silica	65.76	3.42
REDUCE WITH THE FOLLOWING		
50% Wt. Med. Alkyd - Volume Solids 41%	116.20	15.17
Mineral Spirits	44.06	6.77
Lead Drier 36%	1.53	0.13
Calcium Drier 65	1.00	0.13
Cobalt Drier 12%	0.66	0.07
Manganese Drier 9%	0.37	0.04
Anti-Skin	0.96	0.12
HOLD FOR SHADING AND VISCOSITY		
Maroon Shading Paste	20.12	2.70
Diatomaceous Silica	9.70	0.50
Mineral Spirits	18.94	2.91
TOTAL	1,054.25	100.00

Theoretical Weight per Gallon = 10.54
Volume Solids = 39.0%
Weight Solids = 62.5%

FIGURE 28

MIL-E-52798A, ENAMEL ALKYD, LEAD FREE, FOREST GREEN, TYPE II
CONVENTIONAL FORMULATION

	Pounds	Gallons
PREMIX AND GRIND		
Mineral Spirits, Rule 66	74.99	11.52
Bentone 34	11.52	0.76
MIX UNDER HOCKMEYER - THEN ADD		
Diacetone Alcohol	1.26	0.16
MIX UNTIL PASTE GELS - THEN ADD		
50% Wt. Alkyd Resin - Volume Solids 41%	218.84	28.72
Exkin #2	0.80	0.10
Wetting Agent	7.53	0.96
Talc	89.37	3.76
Cobalt Green	71.13	1.64
Chromium Oxide	128.00	3.00
Brown Iron Oxide	4.80	0.10
Organic Brown	12.48	0.99
COVER FOR PREMIX		
Mineral Spirits, Rule 66	6.25	0.96
SAND MILL TO #5 GRIND		
1ST MILL WASH		
50% Wt. Alkyd Resin - Volume Solids 41%	14.70	1.92
Mineral Spirits	12.50	1.92
2ND MILL WASH		
Mineral Spirits	12.50	1.92
REDUCE WITH THE FOLLOWING		
50% Wt. Alkyd Resin - Volume Solids 41%	174.12	22.73
SIFT IN AND AGITATE TO #5 GRIND		
Diatomaceous Silica	90.04	4.68
REDUCE WITH THE FOLLOWING		
Mineral Spirits	61.11	9.38
Exkin #2	0.80	0.10
Calcium Drier 6%	1.06	0.14
Cobalt Drier 12%	1.79	0.21
Manganese Drier 9%	1.04	0.13
Zirco Drier 12%	3.03	0.37

Continued. . . .

FIGURE 28

MIL-E-52798A, ENAMEL ALKYD, LEAD FREE, FOREST GREEN, TYPE II
CONVENTIONAL FORMULATION (CON'T.)

	Pounds	Gallons
WHITE TILE FOR DRY AND GLOSS CHECK: .004 DB (2 MILS WET) 1 DEG. MAX @ 60° 3 DEG. MAX. @ 85°		
HOLD FOR VISCOSITY, SHADING AND GLOSS		
Mineral Spirits	12.50	1.92
Carbazole Violet Shading Paste	14.28	1.91
TOTAL	1,026.44	100.00

Theoretical Weight per Gallon = 10.27
Volume Solids = 37.8%
Weight Solids = 60% Min.

FIGURE 29

MIL-E-52798A, BEADED AIR DRY ALKYD,
FOREST GREEN, TYPE I
FINAL OFF-MILL FORMULATION

	Pounds	Gallons
Mineral Spirits	69.62	10.69
Bentone #38	7.98	0.56
Diacetone Alcohol	2.64	0.33
50% Wt. Alkyd Resin - Volume Solids 41%	332.36	43.43
Anti-Skinning Agent	1.01	0.13
Cobalt Green	84.63	1.95
Chromium Oxide	110.00	2.58
Medium Chrome Yellow	5.11	0.11
Molybdate Orange	20.46	0.42
25 Micron Clear Vesiculated Beads	40.93	12.03
Mineral Spirits	34.83	5.23
SAND MILL THE ABOVE TO 4 N.S.		
LET DOWN		
50% Wt. Alkyd Resin - Volume Solids 41%	102.12	13.35
Mineral Spirits	36.31	5.57
Lead Drier 36%	1.62	0.14
Calcium Drier 6%	1.06	0.14
Cobalt Drier 12%	0.70	0.08
Manganese Drier 9%	0.40	0.05
Anti-Skinning Agent	1.01	0.13
Mineral Spirits	19.98	3.07
TOTAL	872.77	100.00

Theoretical Weight per Gallon = 8.72
Volume Solids = 40.92%
Weight Solids = 55.72%

FIGURE 30

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-E-52798A, ENAMEL ALKYD, FOREST GREEN, TYPE I
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	9.24	27.05

	x	y	z	Lx	Ly
Color Measurements	5.62	7.17	6.22	0.330831	0.35808

	% Reflectance/Transmittance
Infrared Reflectance Average	35.24
Visible Near-Red Reflectance Average	8.00
Ratio Visible/Infrared	4.4

60 Degree Gloss	0.2
85 Degree Gloss	0.9

FIGURE 31

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH

MIL-E-52798A, ENAMEL ALKYD, FOREST GREEN, TYPE I
FINAL BEADED FORMULATION

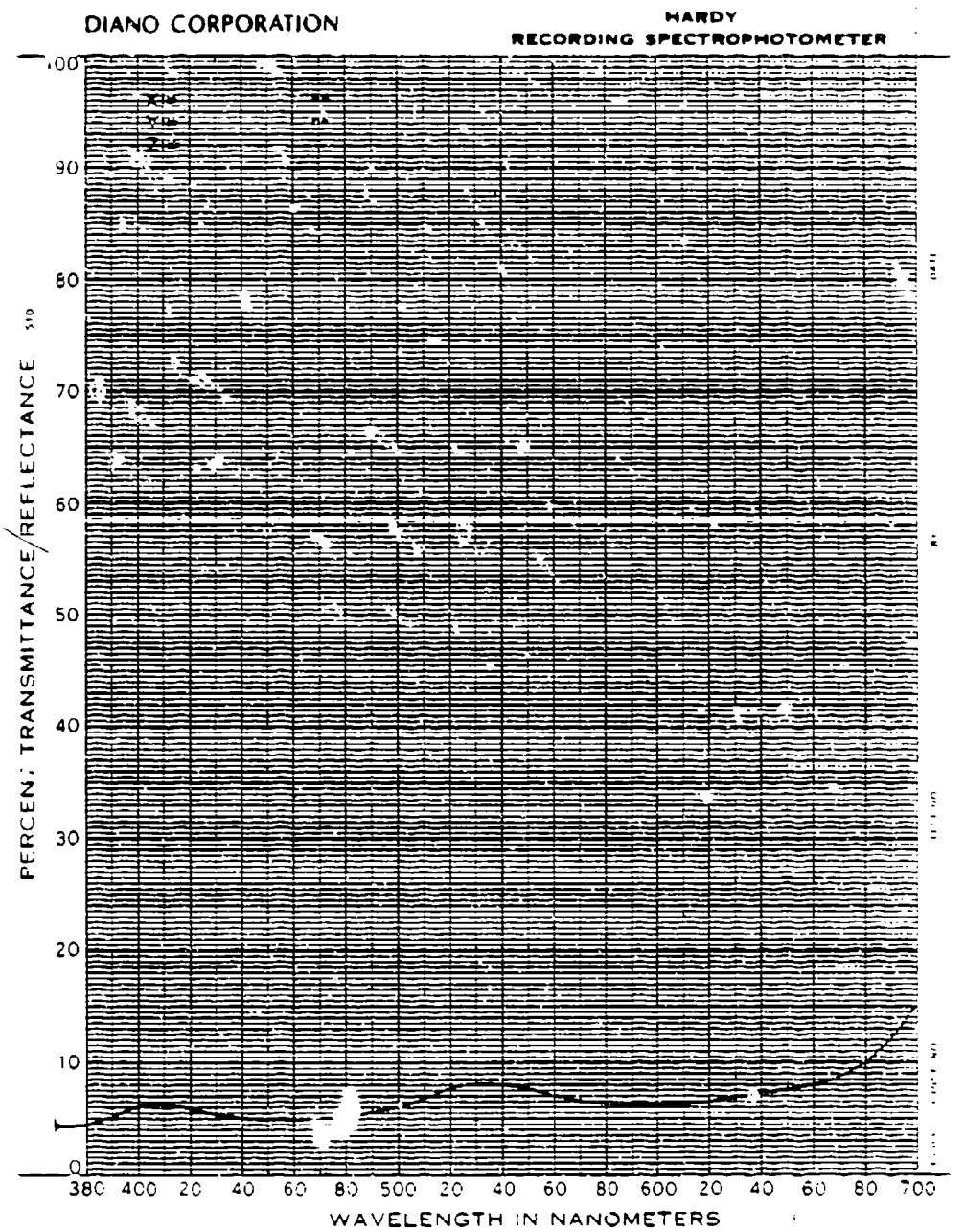

FIGURE 32

MIL-E-52798A(ME) ENAMEL, ALKYD CAMOUFLAGE, AIR DRY, TYPE I
FINAL BEADED FORMULATION

"Y" (B R I G H T N E S S) - . 0 5 8 - . 0 7 5

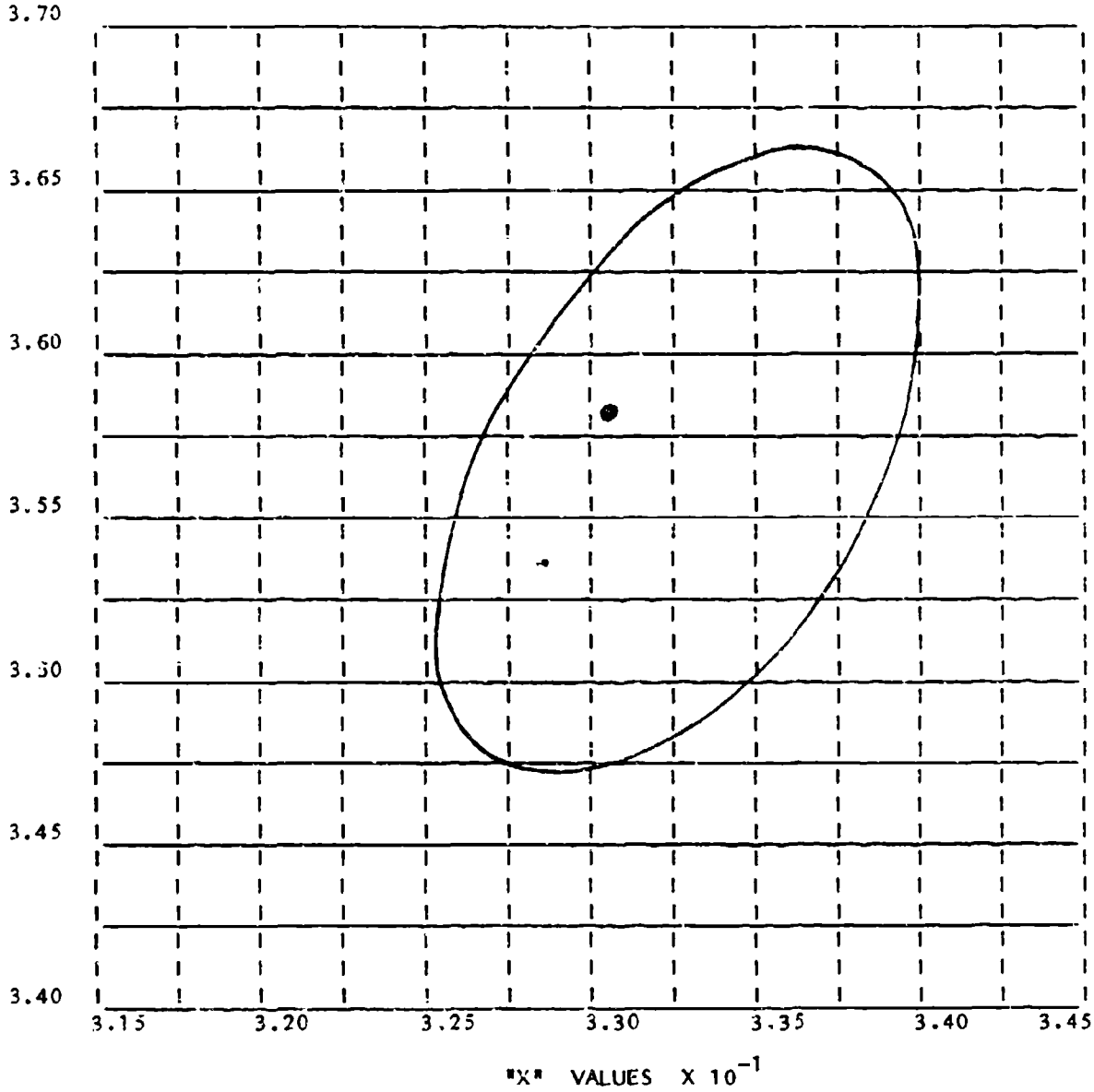

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS
UNITS FROM CENTER VALUES

X - 2795

FIGURE 33

MIL-E-52798A, BEADED AIR DRY ALKYD,
FOREST GREEN, TYPE II
FINAL OFF-MILL FORMULATION

	Pounds	Gallons
Mineral Spirits, Rule 66	75.77	11.64
Bentone #^4	11.64	0.77
Diacetone Alcohol	1.25	0.16
50% Wt. Alkyd Resin - Volume Solids 41%	228.55	29.87
Exkin #2	0.81	0.10
Cobalt Green	97.48	2.26
Chromium Oxide	89.24	2.09
Organic Brown	14.55	1.16
Organic Yellow	6.69	0.54
Yellow Dark Orange Iron Oxide	21.34	0.63
25 Micron Clear Vesiculated Beads	38.80	11.40
SAND MILL THE ASOVE TO 4 N.S.		
LET DOWN		
50% Wt. Alkyd Resin - Volume Solids 41%	168.44	22.00
Mineral Spirits	72.76	11.17
Exkin #2	0.81	0.10
Calcium Drier 6%	1.07	0.14
Cobalt Drier 12%	1.81	0.21
Manganese Drier 9%	1.05	0.13
Zirco Drier 12%	3.07	0.38
Mineral Spirits	25.25	3.88
Carbazole Violet Shading Paste	10.86	1.45
TOTAL	871.28	100.00

Theoretical Weight per Gallon = 8.70
Volume Solids = 41.3%
Weight Solids = 55%

FIGURE 34

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-E-52798A, ENAMEL ALKYD, FOREST GREEN, TYPE II
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	8.42	25.15

	x	y	z	Lx	Ly
Color Measurements	6.66	7.34	6.25	0.328961	0.36243

	% Reflectance/Transmittance
Infrared Reflectance Average	39.32
Visible Near-Red Reflectance Average	7.46
Ratio Visible/Infrared	5.27

60 Degree Gloss	0.3
85 Degree Gloss	1.1

FIGURE 35

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH

MIL-E-52798A, ENAMEL ALKYD, FOREST GREEN, TYPE II
FINAL BEADED FORMULATION

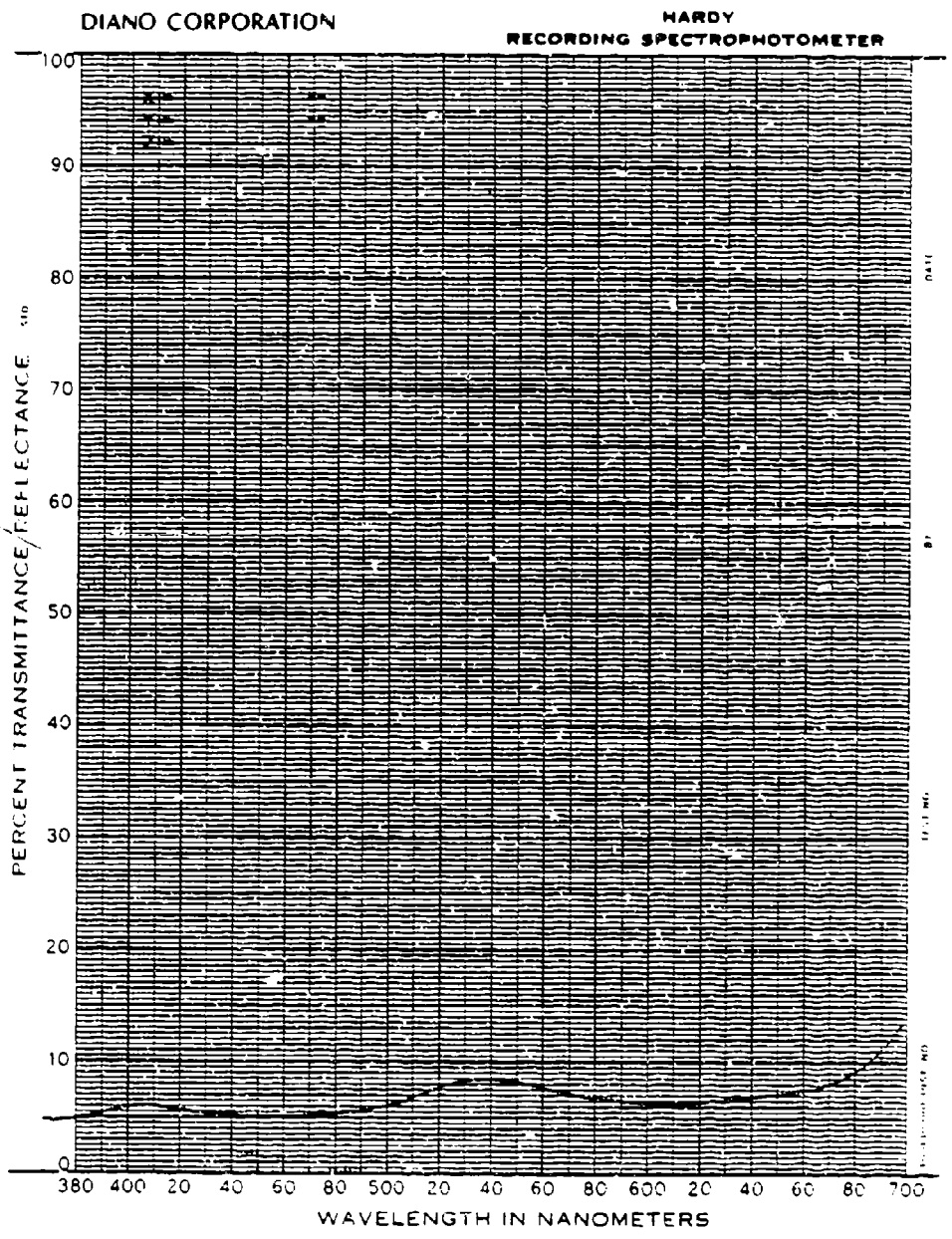

FIGURE 36

MIL-E-52798A(ME) ENAMEL, ALKYD CAMOUFLAGE, AIR DRY, TYPE II
FINAL BEADED FORMULATION

"Y" (B R I G H T N E S S) - . 0 5 8 - . 0 7 5

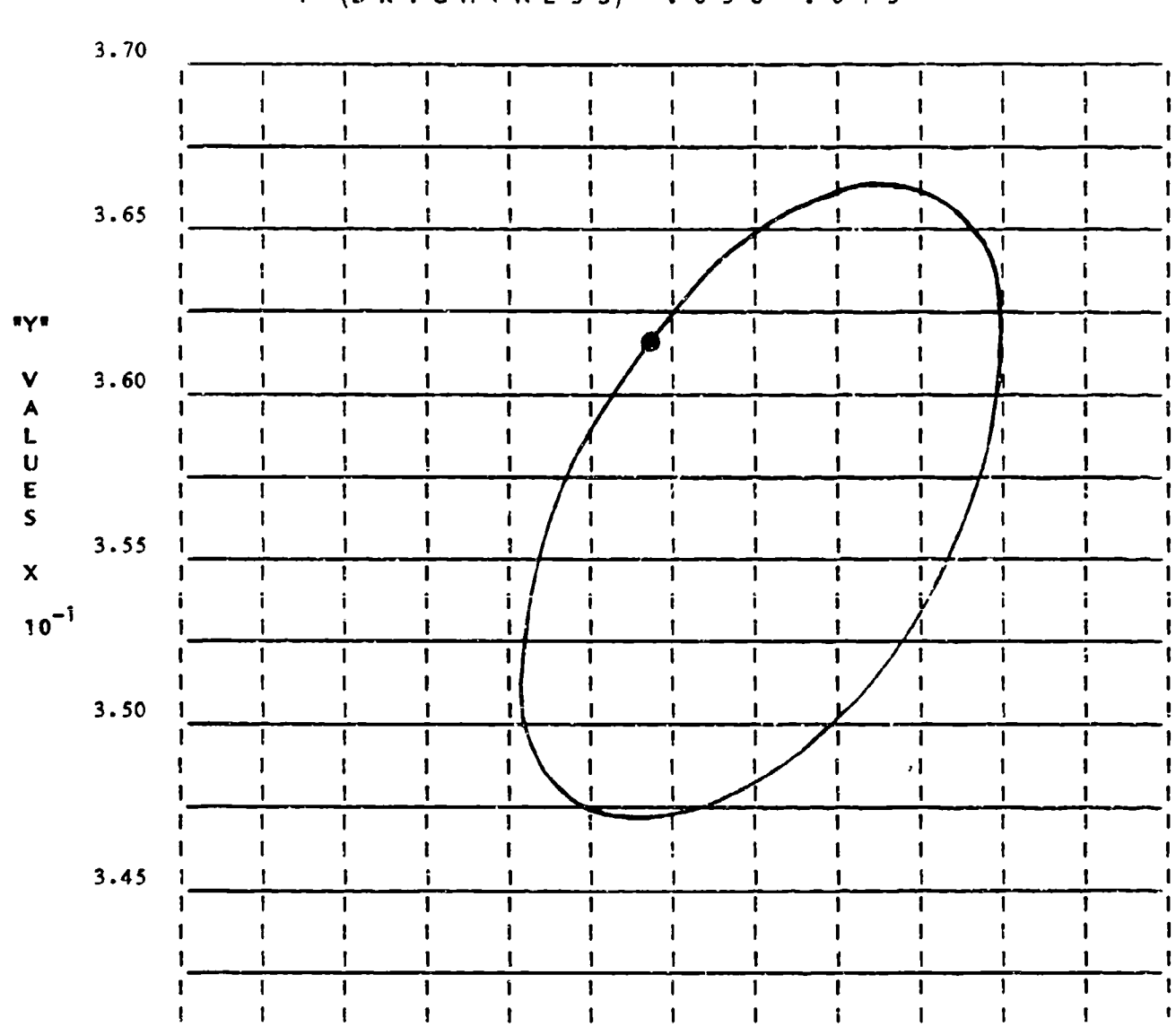

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS
UNITS FROM CENTER VALUES

X - 2795

FIGURE 37

MIL-E-52798A, ENAMEL ALKYD, FOREST GREEN, TYPE I
300 HOUR AND 500 HOUR Q-U-V WEATHER-OMETER PANELS OF
CONVENTIONAL AND BEADED SYSTEMS

VII-7

FIGURE 38

SUMMARY OF Q-U-V WEATHER-OMETER MEASUREMENTS

COMPARISON OF MIL-E-52798A, FOREST GREEN, TYPE I, BEADED VERSUS CONVENTIONAL

Sample	HRS QUV Exposure	670 NM	730 NM	Cap "Y"	Lx	Ly	Gloss 60°	Gloss 85°
Conventional	0	9.45	27.43	7.14	0.330	0.352	0.4	1.2
	25	9.60	27.62	7.31	0.329	0.352	-	-
	50	9.78	27.63	7.55	0.328	0.349	-	-
	75	9.91	27.70	7.71	0.327	0.349	-	-
	150	12.20	29.23	10.23	0.320	0.338	-	-
	300	14.14	31.25	12.14	0.319	0.338	0.4	0.9
	500	14.61	32.03	12.76	0.318	0.341	0.5	0.9
Beaded	0	9.05	26.72	7.03	0.331	0.358	.03	0.6
	25	9.17	26.82	7.14	0.330	0.357	-	-
	50	9.35	26.93	7.35	0.329	0.356	-	-
	75	9.27	26.88	7.28	0.329	0.356	-	-
	150	9.53	26.73	7.73	0.326	0.353	-	-
	300	9.57	27.22	7.72	0.325	0.357	0.2	0.6
	500	10.00	27.89	8.18	0.324	0.359	0.2	0.6

FIGURE 39

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT
FOREST GREEN, TYPE I, PART A (BASE)
CONVENTIONAL STANDARD FORMULATION

	Pounds	Gallons
PREMIX AND GRIND		
Cellosolve Acetate	16.82	2.07
Bentone #27	1.94	0.13
MIX UNDER HOCKMEYER - THEN ADD		
Diacetone Alcohol	1.03	0.13
MIX UNDER HOCKMEYER - THEN ADD		
65% Wt. Polyester Resin - Volume Solids 59%	247.70	26.00
Cellosolve Acetate	26.77	3.30
Butyl Acetate	32.55	4.47
Cobalt Green	222.59	5.12
Medium Chrome Yellow	38.54	0.82
Chromium Oxide	20.77	0.48
Molybdate Orange	19.80	0.40
COVER FOR PREMIX		
Cellosolve Acetate	7.16	0.88
SAND MILL TO #6 GRIND - 1ST MILL WASH		
65% Wt. Polyester Resin - Volume Solids 59%	21.05	2.21
Cellosolve Acetate	17.90	2.21
2ND MILL WASH		
Cellosolve Acetate	17.90	2.21
REDUCE THE FOLLOWING		
Methyl Ethyl Ketone	29.65	4.42
SIFT IN AND AGITATE TO #3 GRIND		
Talc	172.11	7.25
Diatomaceous Silica	105.90	5.50
REDUCE WITH FOLLOWING		
Methyl Ethyl Ketone	154.33	23.00
Butyl Acetate	28.18	3.87
Zinc Octoate	0.52	0.50

Continued . . . .

FIGURE 39

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT
FOREST GREEN, TYPE I, PART A (BASE)
CONVENTIONAL STANDARD FORMULATION (CON'T.)

	Pounds	Gallons
GRIND FOLLOWING TO #6 GRIND ON SAND MILL AND HOLD FOR SHADING		
Carbazole Violet Shading Paste	4.95	0.39
65% Wt. Polyester Resin - Volume Solids 59%	20.29	2.13
Cellosolve Acetate	21.76	2.68
HOLD FOR GLOSS		
Diatomaceous Silica	8.84	0.46
TOTAL	1,239.05	100.00

MIX 4 PARTS "A" BASE TO 1 PART "B" ACTIVATOR

Theoretical Weight per Gallon = 12.40
Volume Solids 35.0%
Weight Solids 62.8%

FIGURE 40

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT
FOREST GREEN, TYPE I, PART A (BASE)
OFF-MILL FORMULATION

	Pounds	Gallons
Cellosolve Acetate	41.78	5.15
Bentone #27	1.58	0.11
Diacetone Alcohol	0.80	0.10
65% Wt. Polyester Resin - Volume Solids 59%	252.19	26.46
Cellosolve Acetate	37.74	5.18
Cobalt Green	157.97	3.65
Chromium Oxide	69.23	1.62
Organic Brown	13.00	1.05
Medium Chrome Yellow	39.50	0.88
Molybdate Orange	7.89	0.15
25 Micron Clear Vesiculated Beads	61.33	18.03
SAND MILL THE ABOVE TO 4 N.S.		
LET DOWN		
Cellosolve Acetate	43.80	6.33
Methyl Ethyl Ketone	174.92	26.07
Butyl Acetate	37.74	5.18
Zinc Octoate 22%	0.45	0.05
TOTAL	939.92	100.00

MIX 4 PARTS "A" BASE TO 1 PART "B" ACTIVATOR

Theoretical Weight per Gallon = 9.39
Volume Solids = 41.1%
Weight Solids = 54.7%

FIGURE 41

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
FOREST GREEN, TYPE I
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	8.53	28.32

	x	y	z	Lx	Ly
Color Measurements	6.83	7.25	6.62	0.329871	0.35046

	% Reflectance/Transmittance
Infrared Reflectance Average	46.94
Visible Near-Red Reflectance Average	7.70
Ratio Visible/Infrared	6.09

60 Degree Gloss	0.5
85 Degree Gloss	1.3

FIGURE 42

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
FOREST GREEN, TYPE I
FINAL BEADED FORMULATION

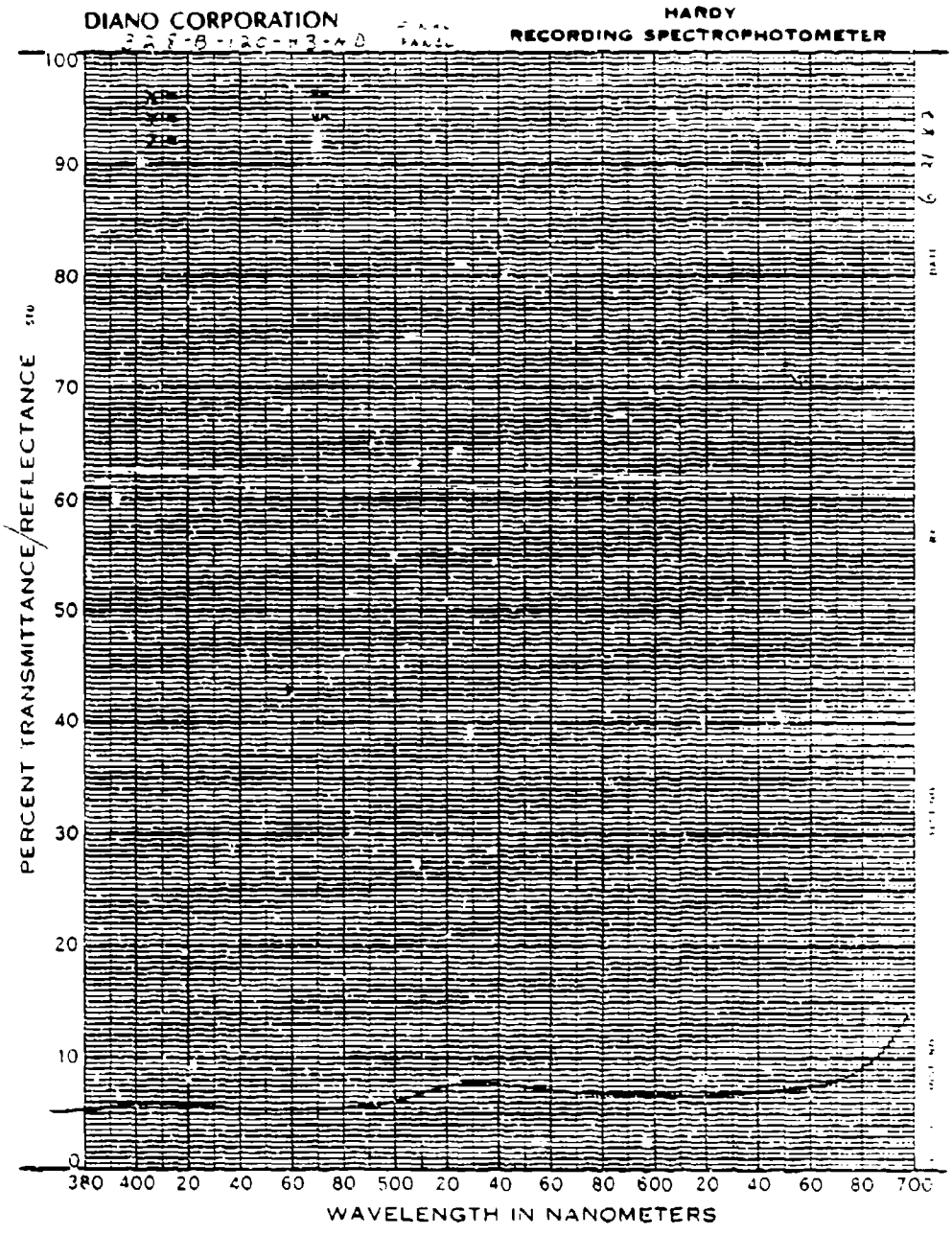

FIGURE 43

MIL-C-46168A(MR) CAMOUFLAGE CHEMICAL AGENT RESISTANT COATING, BEADED, TYPE I
FINAL BEADED FORMULATION

"Y" (BRIGHTNESS) - .058 - .075

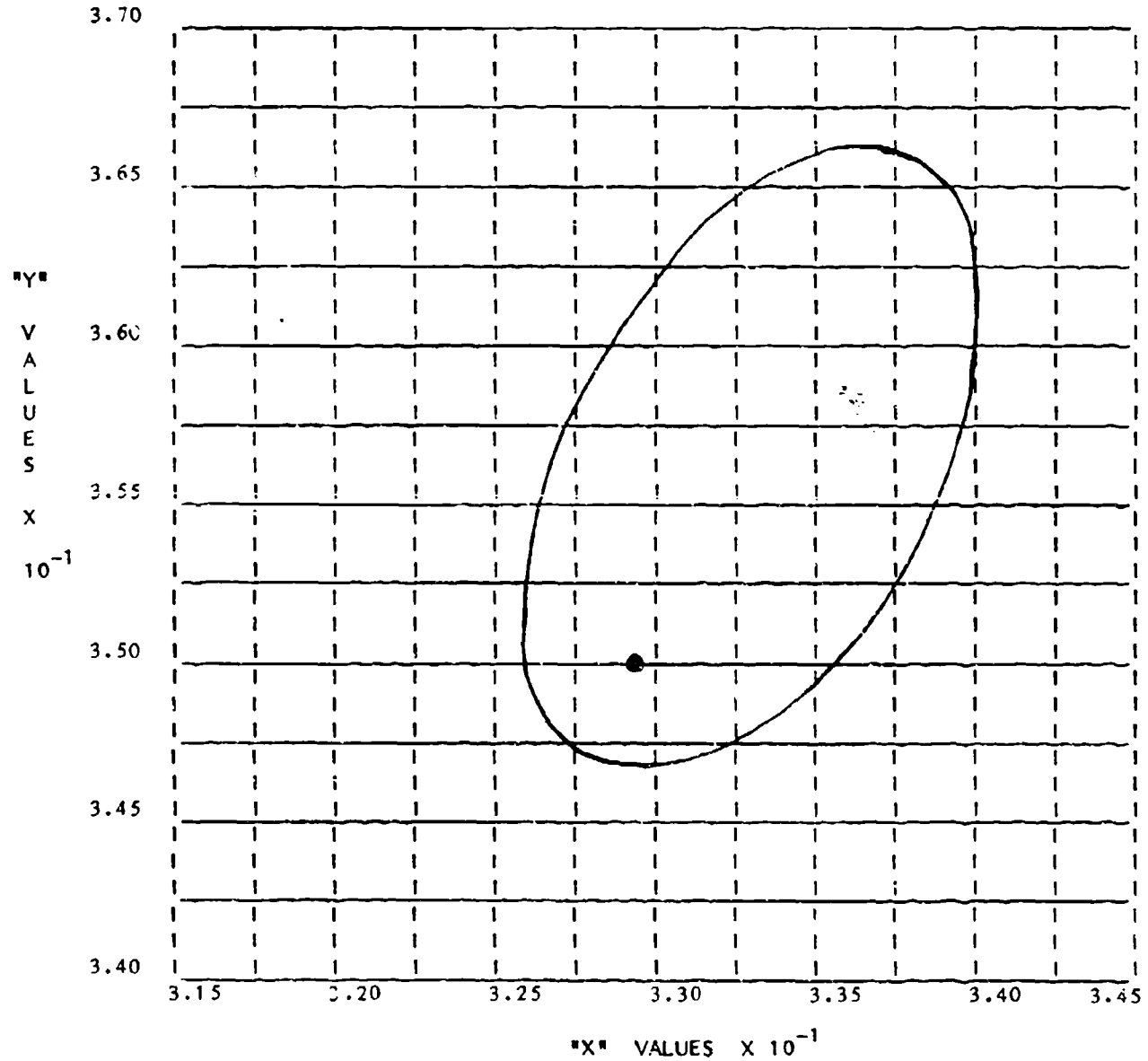

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS
UNITS FROM CENTER VALUES

| X - 2795 |

FIGURE 44

SUMMARY OF Q-U-V WEATHER-OMETER MEASUREMENTS

COMPARISON OF MIL-E-46168A, FOREST GREEN, TYPE I, BEADED VERSUS CONVENTIONAL

Sample	HRS QUV Exposure	670 NM	730 NM	Cap "Y"	Lx	Ly	Gloss 60°	Gloss 85°
Conventional	0	9.0	30.89	7.45	0.329	0.350	0.6	1.8
	25	9.04	30.95	7.48	0.329	0.350	-	-
	50	9.11	31.05	7.60	0.329	0.350	-	-
	75	9.25	31.12	7.78	0.327	0.349	-	-
	150	10.21	31.59	8.84	0.325	0.346	-	-
	300	10.84	32.46	9.42	0.324	0.346	0.5	1.8
	500	11.38	33.28	10.02	0.322	0.345	0.5	1.7
Beaded	0	8.53	28.16	7.32	0.329	0.350	-	-
	25	8.53	28.27	7.29	0.329	0.350	-	-
	50	8.59	28.37	7.41	0.329	0.350	-	-
	75	8.49	28.24	7.31	0.329	0.351	-	-
	150	8.55	27.98	7.55	0.326	0.350	-	-
	300	8.14	28.15	7.19	0.325	0.352	-	-
	500	8.07	28.19	7.19	0.324	0.354	-	-

FIGURE 45

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT
FOREST GREEN, TYPE II, PART A (BASE)
FINAL OFF-MILL FORMULATION

	Pounds	Gallons
Cellosolve Acetate	99.88	12.33
Bentone #34	6.82	0.44
Diacetone Alcohol	1.32	0.16
65% Wt. Polyester Resin - Volume Solids 59%	212.00	22.27
25 Micron Clear Vesiculated Beads	59.53	17.50
Cobalt Green	112.76	2.59
Chromium Oxide	76.67	1.79
Organic Brown	11.72	0.93
Organic Yellow	38.33	2.37
SAND MILL THE ABOVE TO 4 GRIND		
LET DOWN		
Cellosolve Acetate	42.52	5.47
65% Wt. Polyester Resin - Volume Solids 59%	21.48	2.25
Methyl Ethyl Ketone	176.49	26.33
Cellosolve Acetate	26.58	3.27
Polyester Resin	21.56	2.26
Zinc Octoate 22%	0.51	0.04
TOTAL	908.17	100.00

MIX 4 PARTS "A" BASE TO 1 PART "B" ACTIVATOR

Theoretical Weight per Gallon = 9.10
Volume Solids = 41%
Weight Solids = 52%

FIGURE 46

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
FOREST GREEN, TYPE II
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	8.37	27.90

	x	y	z	Lx	Ly
Color Measurements	6.57	7.12	6.26	0.329171	0.35710

	% Reflectance/Transmittance
Infrared Reflectance Average	45.157
Visible Near-Red Reflectance Average	7.52
Ratio Visible/Infrared	6.0

60 Degree Gloss	0.9
85 Degree Gloss	1.2

FIGURE 47

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT, BLACK, (LOW GLOSS), PART A (BASE)
FINAL BEADED FORMULATION

	Pounds	Gallons
Cellosolve Acetate	25.30	3.12
Bentone #27	2.00	0.13
Diacetone Alcohol	1.21	0.16
65% Wt. Polyester Resin - Volume Solids 59%	271.00	28.50
Cellosolve Acetate	137.00	17.00
Carbon Black	44.00	3.12
Black Iron Oxide	65.00	1.60
Butyl Acetate	61.00	8.50
Methyl Ethyl Ketone	21.20	3.20
25 Micron Clear Vesiculated Beads	43.00	12.62
SAND MILL THE ABOVE TO 4 N.S.		
LET DOWN		
Methyl Ethyl Ketone	143.00	22.00
Zinc Octoate 22%	0.52	0.05
TOTAL	814.23	100.00

Theoretical Weight per Gallon = 8.14
Volume Solids = 34.30%
Weight Solids 40.50%

FIGURE 48

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
BLACK, (LOW GLOSS), PART A (BASE)
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	4.53	4.60

	x	y	z	Lx	Ly
Color Measurements	4.36	4.41	5.26	0.31062	0.31444

	% Reflectance/Transmittance
Infrared Reflectance Average	4.65
Visible Near-Red Reflectance Average	4.49
Ratio Visible/Infrared	1.03

60 Degree Gloss	1.2
85 Degree Gloss	1.1

FIGURE 49

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT, FIELD DRAB, PART A (BASE)
FINAL BEADED FORMULATION

	Pounds	Gallons
Cellosolve Acetate	32.28	4.00
Bentone #34	2.50	0.18
Diacetone Alcohol	1.40	0.18
65% Wt. Polyester Resin - Volume Solids 59%	380.00	40.00
Cellosolve Acetate	138.00	17.00
Chromium Oxide	115.00	2.70
Yellow Dark Orange Oxide	145.00	4.32
Red Oxide	23.00	0.56
Titanium Dioxide	3.70	0.11
25 Micron Clear Vesiculated Beads	53.00	15.45
SAND MILL THE ABOVE TO 4 N.S.		
LET DOWN		
Cellosolve Acetate	32.00	4.00
Butyl Acetate	49.00	6.70
Methyl Ethyl Ketone	24.50	3.72
Zinc Octoate 22%	0.80	0.08
SHADE WITH		
Carbon Black Paste	9.40	1.00
TOTAL	1,009.58	100.00

MIX 4 PARTS "A" (BASE) TO 1 PART "B" (ACTIVATOR)

Theoretical Weight per Gallon = 10.10
Volume Solids = 47.27%
Weight Solids = 58.64%

FIGURE 50

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
FIELD DRAB, PART A (BASE)
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	16.88	24.49

	x	y	z	Lx	Ly
Color Measurements	10.95	10.84	6.55	0.386461	0.38251

	% Reflectance/Transmittance
Infrared Reflectance Average	27.1
Visible Near-Red Reflectance Average	14.68
Ratio Visible/Infrared	1.84

60 Degree Gloss	0.2
85 Degree Gloss	1.8

FIGURE 51

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT, OLIVE DRAB, PART A (BASE)
FINAL BEADED FORMULATION

	Pounds	Gallons
Cellosolve Acetate	72.60	9.00
Bentone #34	6.70	0.45
Diacetone Alcohol	0.90	0.11
65% Wt. Polyester Resin - Volume Solids 59%	292.00	30.60
Cellosolve Acetate	161.40	20.00
Modaflow Solution - Volume Solids 50%	4.32	0.56
Yellow Dark Orange Oxide	169.00	5.10
Red Oxide	20.00	0.50
Titanium Dioxide	19.00	0.57
Phthalo Blue	8.00	0.60
25 Micron Clear Vesiculated Beads	43.00	12.75
SAND MILL THE ABOVE TO 5 N.S.		
LET DOWN		
Cellosolve Acetate	26.00	3.20
Methyl Ethyl Ketone	109.00	16.50
Zinc Octoate 22%	0.67	0.06
TOTAL	932.59	100.00

MIX 4 PARTS "A" (BASE) TO 1 PART "B" (ACTIVATOR)

Theoretical Weight per Gallon = 9.33
Volume Solids = 38.30%
Weight Solids = 49.00%

FIGURE 52

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
OLIVE DRAB, PART A (BASE)
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	11.70	13.48

	x	y	z	Lx	Ly
Color Measurements	8.97	9.13	6.19	0.369161	0.37600

	% Reflectance/Transmittance
Infrared Reflectance Average	23.4
Visible Near-Red Reflectance Average	7.68
Ratio Visible/Infrared	3.04

60 Degree Gloss	0.3
85 Degree Gloss	2.8

FIGURE 53

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT, SAND, PART A (BASE)
FINAL BEADED FORMULATION

	Pounds	Gallons
Cellosolve Acetate	21.80	2.70
Bentone #27	1.90	0.13
Diacetone Alcohol	1.05	0.13
65% Wt. Polyester Resin - Volume Solids 59%	292.00	30.70
Cellosolve Acetate	76.80	9.51
Butyl Acetate	72.78	10.00
Titanium Dioxide	155.00	4.65
Yellow Oxide	31.00	0.92
Red Oxide	5.40	0.12
Chromium Oxide	27.50	0.65
25 Micron Clear Vesiculated Beads	53.00	15.45
SAND MILL THE ABOVE TO 4 N.S.		
LET DOWN		
Cellosolve Acetate	110.00	13.81
Methyl Ethyl Ketone	74.12	11.18
Zinc Octoate 22%	0.53	0.05
TOTAL	922.88	100.00

MIX 4 PARTS "A" (BASE) TO 1 PART "B" (ACTIVATOR)

Theoretical Weight per Gallon = 9.23
Volume Solids = 40.00%
Weight Solids = 50.24%

FIGURE 54

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
SAND, PART A (BASE)
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	39.03	51.95

	x	y	z	Lx	Ly
Color Measurements	28.19 L	28.79 L	20.68 L	0.36295L	0.37070

	% Reflectance/Transmittance
Infrared Reflectance Average	57.23
Visible Near-Red Reflectance Average	35.15
Ratio Visible/Infrared	1.62
60 Degree Gloss	0.5
85 Degree Gloss	2.7

FIGURE 55

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
AIRCRAFT INSIGNIA BLUE, PART A (BASE)
FINAL BEADED FORMULATION

	Pounds	Gallons
Cellosolve Acetate	233.40	28.75
Bentone #34	3.00	0.20
Diacetone Alcohol	1.30	0.15
65% Wt. Polyester Resin - Volume Solids 59%	274.00	28.75
75% Wt. Saturated Polyester - Volume Solids 71.5%	69.30	7.50
Phthalo Blue Green Shade	43.00	3.30
General Carbon Lamp Black	53.00	15.59
SAND MILL THE ABOVE TO 5 N.S.		
LET DOWN		
Cellosolve Acetate	50.00	6.17
Butyl Acetate	66.00	9.20
Zinc Octoate 22%	0.70	0.07
TOTAL	798.50	100.00

MIX 4 PARTS "A" (BASE) TO 1 PART "B" (ACTIVATOR)

Theoretical Weight per Gallon = 7.99
Volume Solids = 41.73%
Weight Solids = 41.82

FIGURE 56

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
AIRCRAFT INSIGNIA BLUE, PART A (BASE)
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	3.84	4.48

	x	y	z	Lx	Ly
Color Measurements	3.91	3.81	5.92	0.286431	0.27933

	% Reflectance/Transmittance
Infrared Reflectance Average	7.4
Visible Near-Red Reflectance Average	4.17
Ratio Visible/Infrared	1.77

60 Degree Gloss	0.5
85 Degree Gloss	1.0

FIGURE 57

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT, AIRCRAFT WHITE, PART A (BASE)
FINAL BEADED FORMULATION

	Pound	Gallons
Cellosolve Acetate	134.00	16.50
Bentone #34	2.28	0.15
Diacetone Alcohol	0.93	0.12
65% Wt. Polyester Resin - Volume Solids 59%	199.18	20.90
75% Wt. Saturated Polyester - Volume Solids 71.5%	56.86	6.18
Titanium Dioxide	345.00	10.34
25 Micron Clear Vesiculated Beads	39.00	11.47
SAND MILL THE ABOVE TO 5 N.S.		
LET DOWN		
Cellosolve Acetate	106.00	13.23
Methyl Ethyl Ketone	80.31	12.00
Butyl Acetate	65.89	9.05
Zinc Octoate 22%	0.55	0.06
TOTAL	1,030.00	100.00

MIX 4 PARTS "A" (BASE) TO 1 PART "B" (ACTIVATOR)

Theoretical Weight per Gallon = 10.30
Volume Solids = 38.70%
Weight Solids = 54.30%

FIGURE 58

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
AIRCRAFT WHITE, PART A (BASE)
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	90.57	89.78

	x	y	z	Lx	Ly
Color Measurements	89.55	91.74	107.251	0.310341	0.31796

	% Reflectance/Transmittance
Infrared Reflectance Average	89.22
Visible Near-Red Reflectance Average	91.04
Ratio Visible/Infrared	0.98

60 Degree Gloss	3.0
85 Degree Gloss	4.1

FIGURE 59

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT, AIRCRAFT BLACK, PART A (BASE)
FINAL BEADED FORMULATION

	Pounds	Gallons
Cellosolve Acetate	131.50	16.30
Bentone #34	2.20	0.15
Diacetone Alcohol	0.90	0.12
65% Wt. Polyester Resin - Volume Solids 59%	220.00	23.00
75% Wt. Saturated Polyester - Volume Solids 71.5%	56.00	6.00
Butyl Acetate	70.00	9.70
Carbon Black	39.00	2.68
Black Iron Oxide	56.00	1.37
25 Micron Clear Vesiculated Beads	43.00	12.62
SAND MILL THE ABOVE TO 5 N.S.		
LET DOWN		
Cellosolve Acetate	32.30	4.00
Methyl Ethyl Ketone	159.12	24.00
Zinc Octoate 22%	0.50	0.06
TOTAL	810.52	100.00

MIX 4 PARTS "A" (BASE) TO 1 PART "B" (ACTIVATOR)

Theoretical Weight per Gallon = 8.11
Volume Solids = 34.70%
Weight Solids = 40.12%

FIGURE 60

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
AIRCRAFT BLACK, PART A (BASE)
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	4.12	4.17

	x	y	z	Lx	Ly
Color Measurements	3.99	4.05	4.78	0.311181	0.31599

	% Reflectance/Transmittance
Infrared Reflectance Average	4.24
Visible Near-Red Reflectance Average	4.09
Ratio Visible/Infrared	1.036

60 Degree Gloss	0.9
85 Degree Gloss	0.6

FIGURE 61

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT, AIRCRAFT GREEN, PART A (BASE)
FINAL BEADED FORMULATION

	Pounds	Gallons
Cellosolve Acetate	72.70	9.90
Bentone #27	1.30	0.10
Diacetone Alcohol	0.80	0.10
65% Wt. Polyester Resin - Volume Solids 59%	284.70	30.00
Yellow Iron Oxide	78.70	2.35
Carbon Black	21.30	1.60
Black Iron Oxide	32.30	0.78
Red Oxide	20.60	0.50
SAND MILL THE ABOVE TO 5 N.S.		
LET DOWN		
Cellosolve Acetate	65.00	8.00
Methyl Ethyl Ketone	100.00	15.10
Zinc Octoate 22%	0.60	0.06
SIFT IN AT HIGH SPEED		
25 Micron Clear Vesiculated Beads	50.00	14.71
DISPERSE THE ABOVE TO 0-1 N.S.		
REDUCE WITH		
Methyl Ethyl Ketone	111.40	16.80
TOTAL	841.40	100.00

MIX 4 PARTS "A" (BASE) TO 1 PART "B" (ACTIVATOR)

Theoretical Weight per Gallon = 7.76
Volume Solids = 37.70%
Weight Solids = 46.50%

FIGURE 62

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
AIRCRAFT GREEN, PART A (BASE)
FINAL BEADED FORMULATION

Wave Length	670	730
% Reflectance/Transmittance	6.31	6.14

	x	y	z	Lx	Ly
Color Measurements	6.25	6.38	6.94	0.319211	0.32590

	% Reflectance/Transmittance
Infrared Reflectance Average	5.93
Visible Near-Red Reflectance Average	6.4
Ratio Visible/Infrared	0.93

60 Degree Gloss	0.7
85 Degree Gloss	1.0

FIGURE 63

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
300 HOUR Q-U-V WEATHER-OMETER OF FIELD DRAB AND BLACK
CONVENTIONAL VERSUS BEADED SYSTEMS

VII-9

FIGURE 64

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT, FOREST GREEN, TYPE II, PART A (BASE) CONTAINING COBALT VESICULATED BEADS

	Pounds	Gallons
PREMIX AND GRIND		
Cellosolve Acetate	91.79	11.33
Bentone 34	6.30	0.42
Diacetone Alcohol	1.23	0.15
MIX UNDER HOCKMEYER - THEN ADD		
65% Wt. Polyester Resin - Volume Solids 59%	214.66	22.98
25 Micron Vesiculated Cobalt Beads	116.00	22.51
Chromium Oxide	145.73	3.43
Organic Brown	12.76	1.02
25 Micron Vesiculated Inert Beads	18.23	3.59
Cellosolve Acetate	39.07	4.82
SAND MILL TO 4 N.S.		
LET DOWN		
65% Wt. Polyester Resin - Volume Solids 59%	19.82	2.08
Methyl Ethyl Ketone	16.22	24.17
Cellosolve Acetate	24.43	3.01
Zinc Octoate	0.49	0.05
Carbazole Violet Shading Paste	3.96	0.44
TOTAL	856.67	100.00

MIX 4 PARTS "A" (BASE) TO 1 PART "B" (ACTIVATOR)

Theoretical Weight per Gallon = 8.56
Volume Solids = 45.7%
Weight Solids = 52.6%

FIGURE 65

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
FOREST GREEN, TYPE II,
CONTAINING COBALT VESICULATED BEADS

Wave Length	670	730
% Reflectance/Transmittance	10.72	27.40

	x	y	z	Lx	Ly
Color Measurements	6.62	7.07	6.53	0.327651	0.34944

	% Reflectance/Transmittance
Infrared Reflectance Average	47.76
Visible Near-Red Reflectance Average	8.40
Ratio Visible/Infrared	5.68

60 Degree Gloss	0.4
85 Degree Gloss	2.8

FIGURE 66

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH,
MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
FOREST GREEN, TYPE II
CONTAINING COBALT VESICULATED BEADS

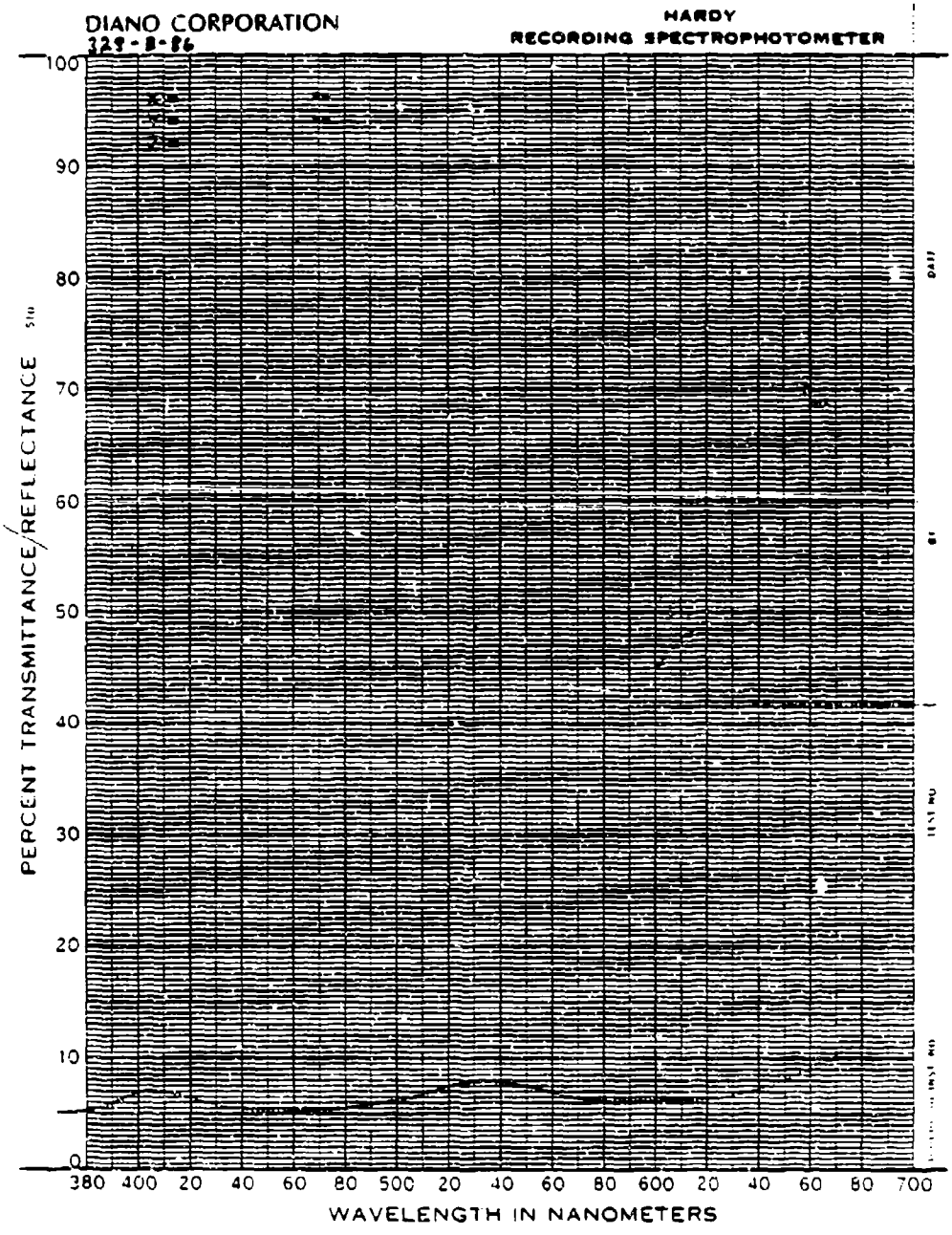

FIGURE 67

MIL-C-46168A (MR) CAMOUFLAGE CHEMICAL AGENT RESISTANT COATING, FOREST GREEN, TYPE II, CONTAINING COBALT VESICULATED BEADS

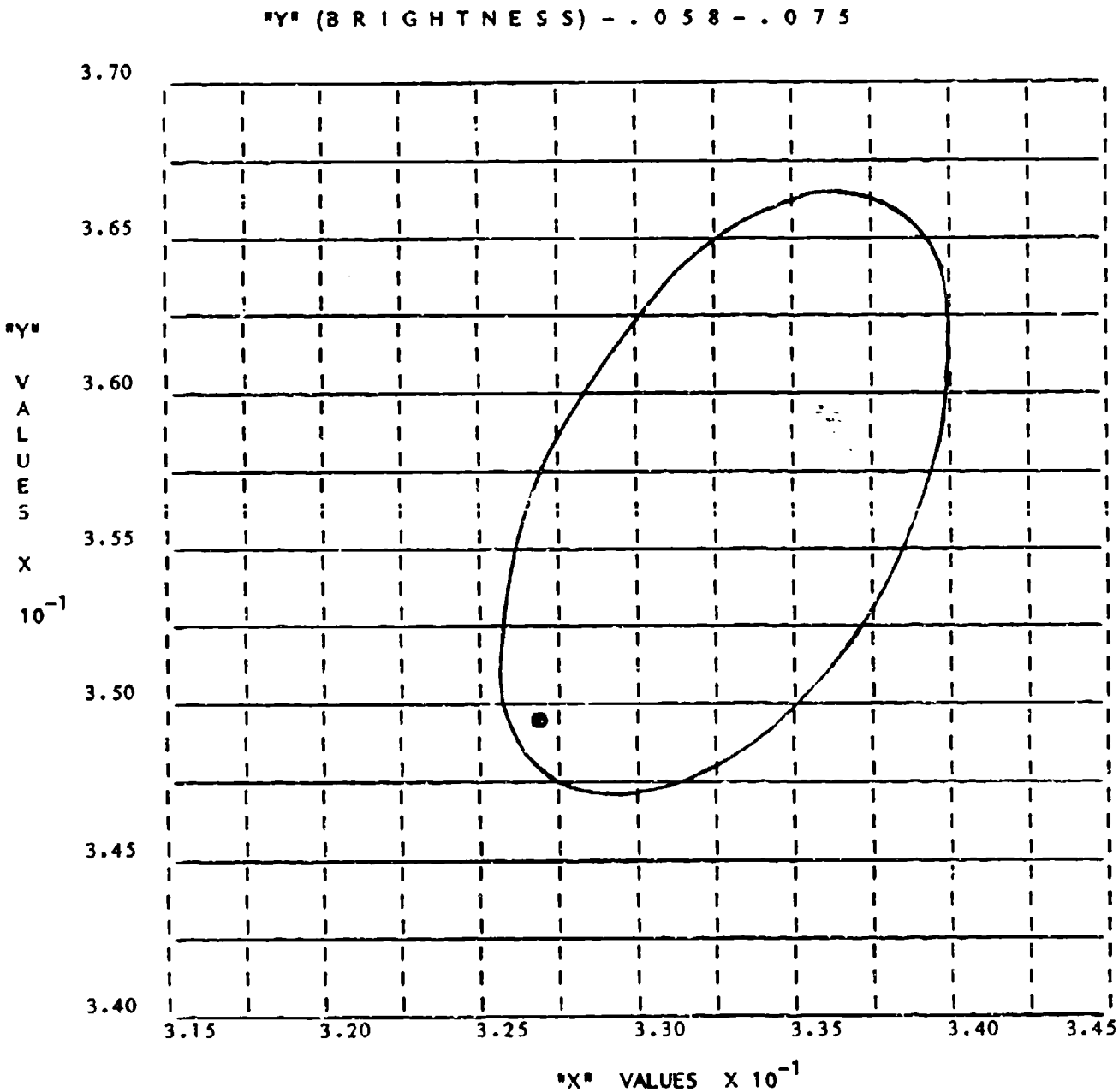

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS
UNITS FROM CENTER VALUES

X - 2795

FIGURE 68

MIL-C-46168A, ALIPHATIC POLYURETHANE,
CHEMICAL AGENT RESISTANT, FOREST GREEN, TYPE I,
PART A (BASE)
CONTAINING PIGMENTED BEADS IN PLACE OF PRIME PIGMENTS

	Pounds	Gallons
PREMIX AND GRIND		
Cellosolve Acetate	66.43	8.20
Bentone 34	4.56	0.30
Diacetone Alcohol	0.89	0.12
MIX UNDER HOCKMEYER - THEN ADD		
65% Wt. Polyester Resin - Volume Solids 59%	169.70	17.80
25 Micron Cobalt Green Vesiculated Beads	56.52	10.66
25 Micron Chrome Oxide Vesiculated Beads	105.48	19.89
25 Micron Brown Solid Beads	9.24	0.80
Methyl Ethyl Ketone	117.39	17.70
Cellosolve Acetate	45.96	5.66
SAND MILL TO 4 N.S.		
LET DOWN		
65% Wt. Polyester Resin - Volume Solids 59%	120.00	12.58
Methyl Ethyl Ketone	42.00	6.26
Zinc Octoate	0.35	0.04
TOTAL	738.52	100.00

MIX 4 PARTS "A" (BASE) TO 1 PART "B" (ACTIVATOR)

Theoretical Weight per Gallon = 7.38
Volume Solids = 49.5%
Weight Solids = 49.3%

FIGURE 69

SUMMARY OF VISIBLE NEAR-RED AND INFRARED
COLOR MEASUREMENTS AND GLOSS MEASUREMENTS

MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
FOREST GREEN, TYPE I,
CONTAINING PIGMENTED BEADS IN PLACE OF PRIME PIGMENTS

Wave Length	670	730
% Reflectance/Transmittance	11.02	26.22

	x	y	z	Lx	Ly
Color Measurements	6.62	7.07	6.29	0.3313	0.3538

	% Reflectance/Transmittance
Infrared Reflectance Average	41.06
Visible Near-Red Reflectance Average	8.5
Ratio Visible/Infrared	48.26

60 Degree Gloss	0.7
85 Degree Gloss	2.8

FIGURE 70

CURVE OF PERCENT REFLECTANCE VERSUS WAVELENGTH
MIL-C-46168A, ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT,
FOREST GREEN, TYPE I,
CONTAINING PIGMENTED BEADS IN PLACE OF PRIME PIGMENTS

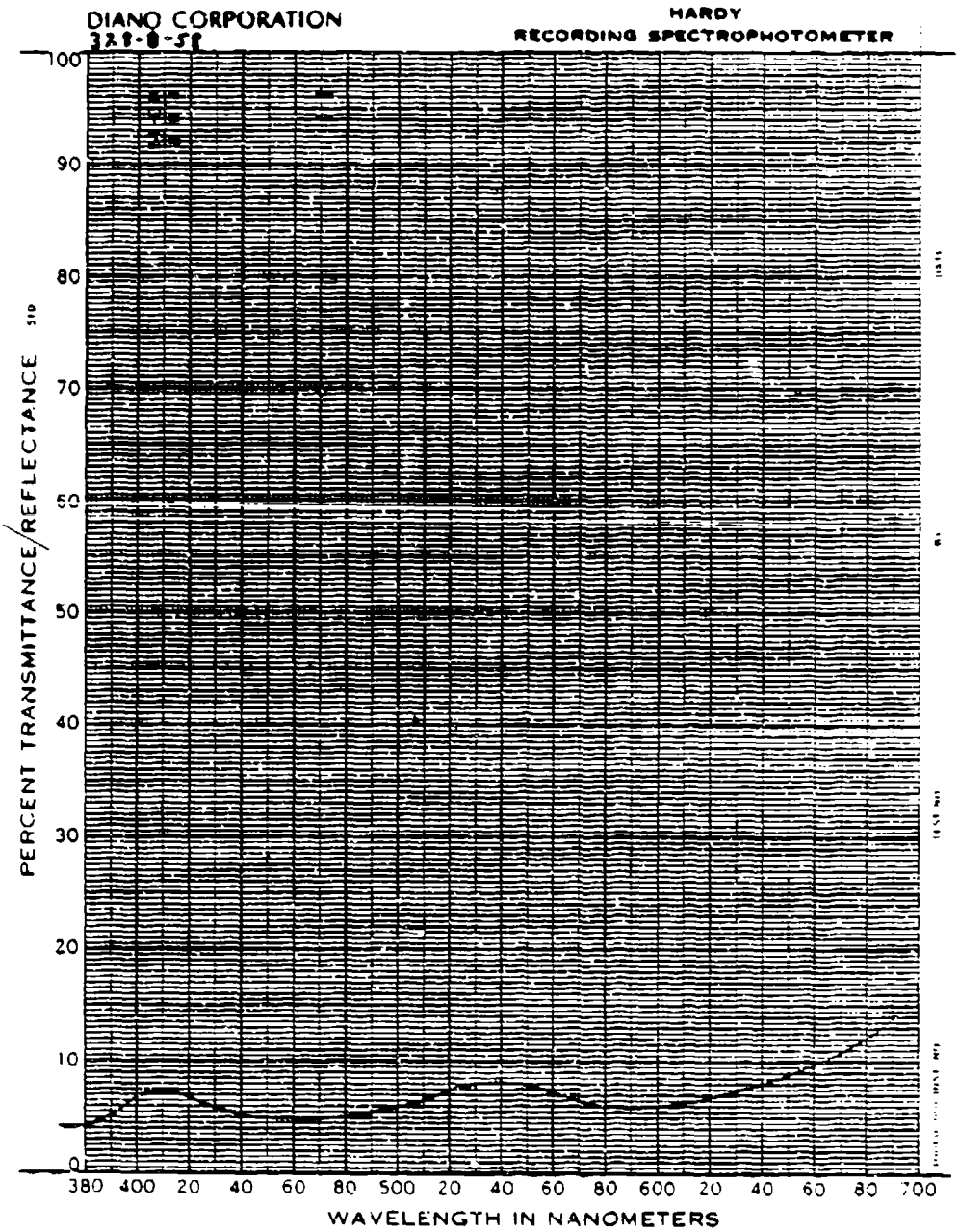

FIGURE 71

MIL-C-46168A(MR), ALIPHATIC POLYURETHANE, CHEMICAL AGENT RESISTANT COATING, FOREST GREEN, TYPE I, CONTAINING PIGMENTED BEADS IN PLACE OF PRIME PIGMENTS

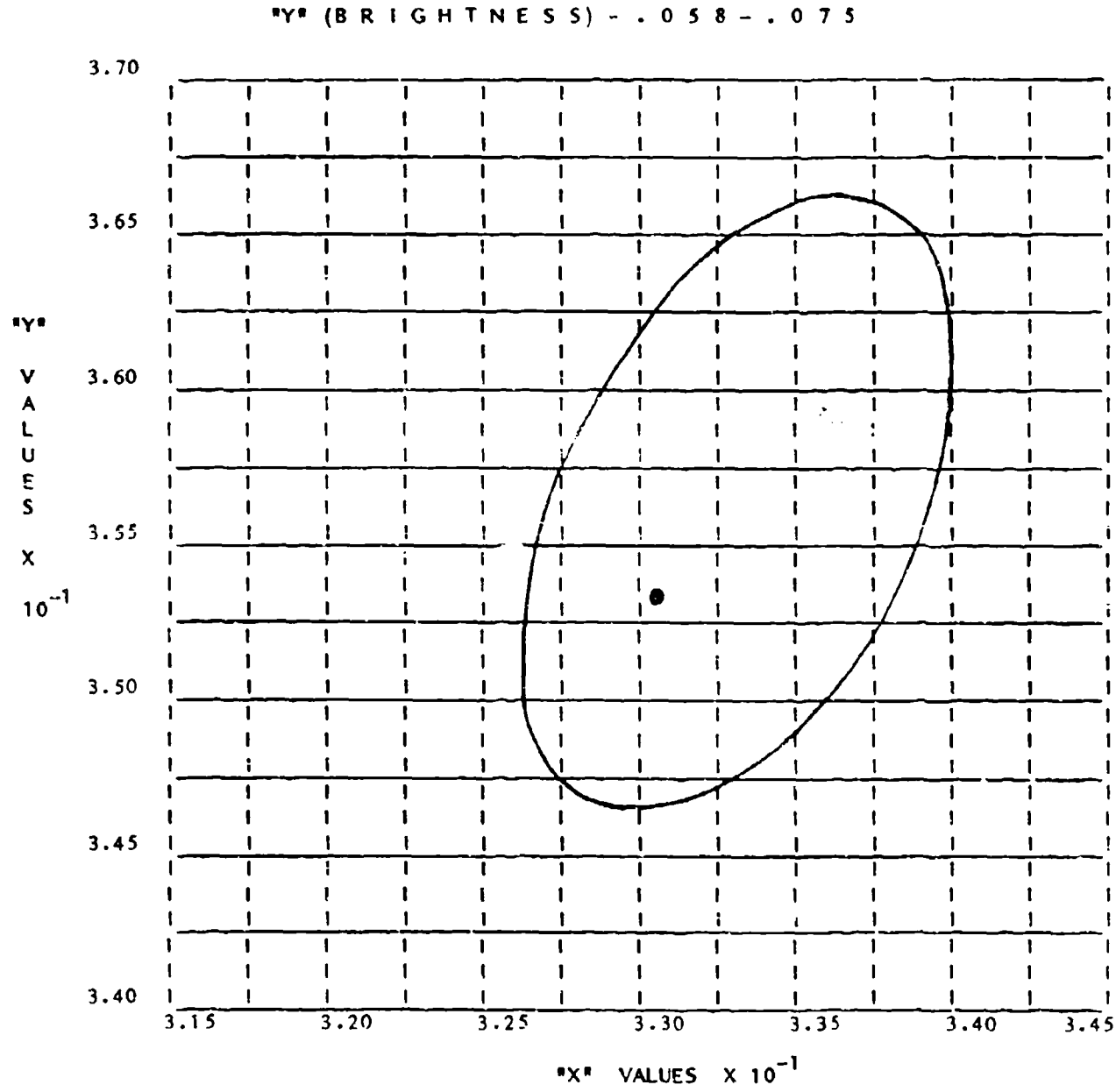

FIGURE 2
CHROMATICITY DIAGRAM FOR CAMOUFLAGE PAINT
COLOR - FOREST GREEN
NOTE: COLOR ELLIPSE IS 2. NBS UNITS FROM CENTER VALUES

X - 2795